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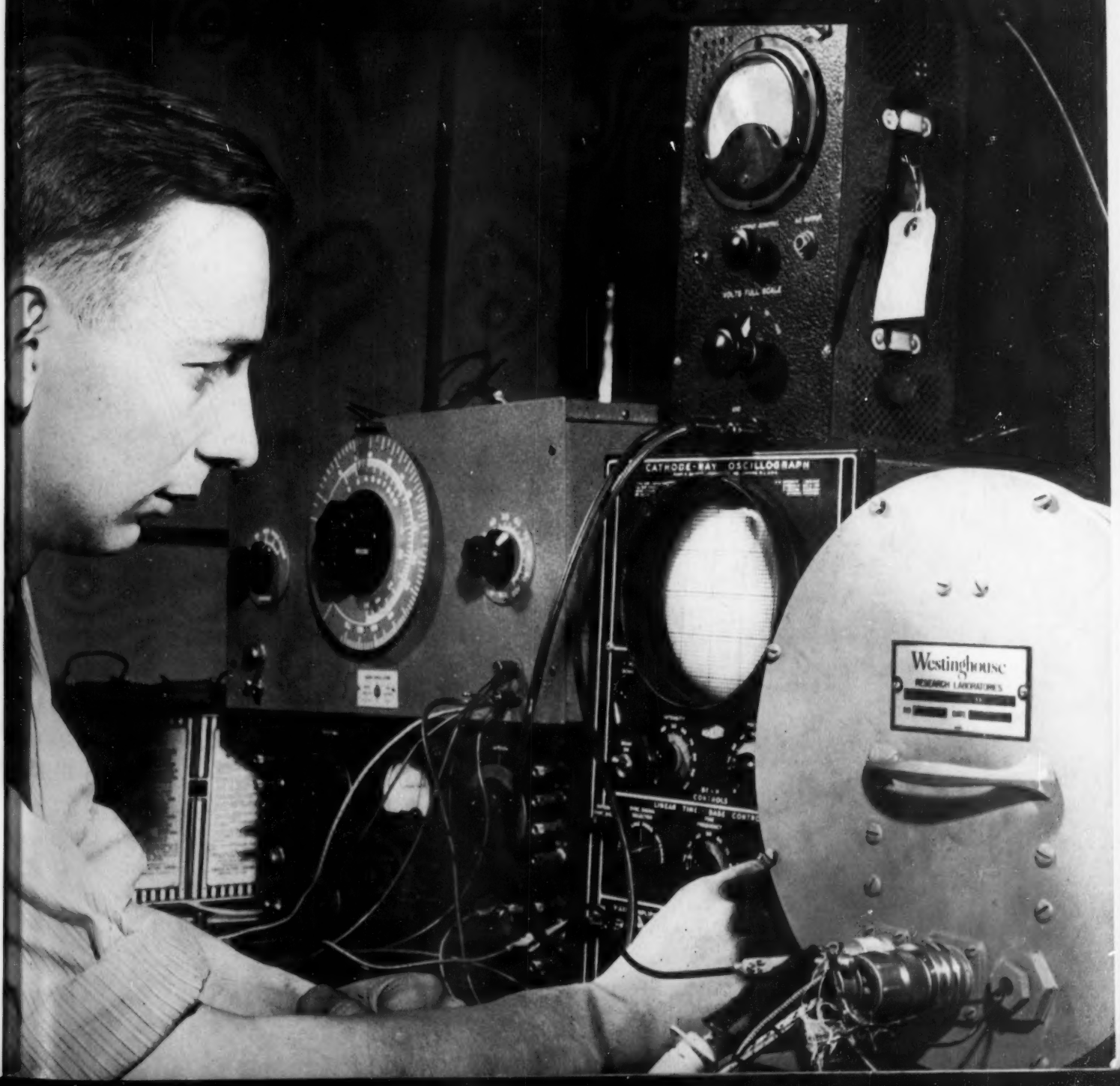
Instruments

THE MAGAZINE OF Measurement and Control



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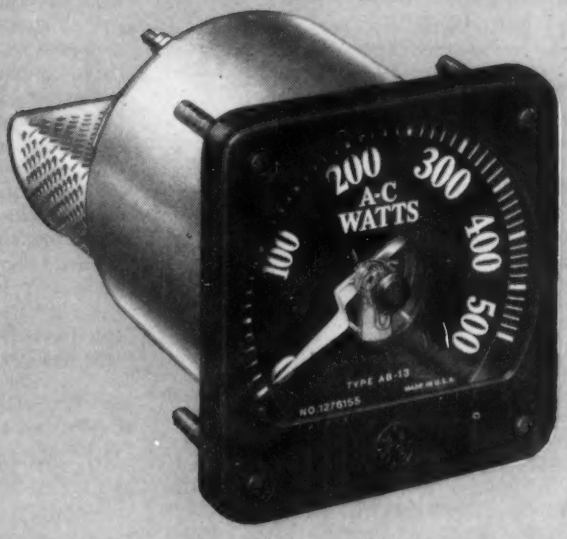

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A-C & D-C

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Instruments
THE MAGAZINE OF Measurement and Control

Vol. 19 July 1946 No. 7

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Will the ISA Conference Usher in a New Era in Instrumentation?

FROM a few glances at just-released publicity giving the titles of a few of the papers to be presented before the ISA Instrumentation Conference in September, it is certain that IMPORTANT DISCLOSURES WILL BE MADE.

To be sure, none will make front-page headlines. The fifty-odd lecturers are not expected to disclose achievements on a par with FM, penicillin, nuclear fission, silicones, JP, radar, transuranic elements, DDT, color television, the betatron, resnatron and other particle-accelerating instruments; or theories on a par with Einstein's; or discoveries on a par with Stern & Estermann's molecular rays.

Neither are these lecturers expected to announce fireless cookers, cordless irons, runless stockings, glareless headlights or other popular items (which rate bigger headlines than scientific achievements).

And it is unlikely that new commercially-available measuring and automatic-control instruments will be announced: some of them will be on display in the Exhibit—in most cases for the first time; all of them are or will be promptly reported in our New Instruments Department; and the Conference lecture platform will probably not be used for commercial plugs.

Indeed, it may well be that the greatest disclosure—the one which will most profoundly influence the future of Instrumentation—will be entirely overlooked by the newspapers and will receive only a few lines in the immediately-following issues of most technical magazines serving other fields than the one with which the lecturer's name is linked. Perhaps this "greatest" disclosure will have little influence even in the lecturer's own special field.

We are not thinking of any particular individual or Conference topic; we are thinking of history, of the years it took for great contributions to win acceptance outside of small circles of specialists.

Fortunately, this handicap of small-circle obscurity will be removed to some extent by the application of modern publicity methods. Preparations are being made to have reporters from newspapers as well as from technical magazines and scientific journals "cover" the Conference. Before the Conference opens, summaries of most of the lectures will be available on request and will be mailed to news syndicates and to technical magazines and scientific journals. Advance copies, complete with illustrations, will be printed as early as mid-August for some of the foresighted authors who will have finished their texts and diagrams by mid-July. Naturally, the September issue of *Instruments* will be a special one, containing the complete program and other special features. As we go to press we learn that *Electronic Industries* will also bring out a Special Instrumentation Issue in September and that other technical magazines will give generous space to the ISA Conference.

Everything is being done to publicize and dramatize the messages to be delivered by at least fifty prominent engineers, scientists, educators and industrial executives. Even the official name, "Instrumentation for Tomorrow," was adopted because of its ACCURACY as well as because of its publicity value. Notices to members of the ISA and of scientific and engineering societies participating in the Conference, as well as public notices, will assure a large attendance from outside Western Pennsylvania. (We've just learned that four Californians have written for hotel-room reservations.) In short, earnest efforts are being exerted to make the great Conference usher in a new era in Instrumentation.

Do you think it will?

Whether you answer yes or no, events will prove to your satisfaction that you were right. A logical prediction would seem to be—

But before stating this prediction, it is in order to look into why it so often took years or decades for great contributions to science and technology to win wide acceptance. Lack of modern communication facilities is the stock answer; and when this answer is doubted, the case of Mendel* is pulled out like an ace-in-the-hole to squelch the doubter.

We've had Mendel pulled on us lots of times and we still doubt the stock answer. We believe, as does a tiny minority, that if Mendel's paper had appeared simultaneously (and without alterations) in all German-language horticultural and other natural-science journals and if exact translations had appeared in all French, English and American natural-science journals, it would only have given the good abbot an enormously greater amount of "name publicity" and would not—as is claimed today—have triggered off in 1865 the new era in genetics which actually began four decades later. We believe that this "IF" is absurd because such publicity would have been refused in 1865: the few real biologists and the many scientific florists and farmers on the scene in 1865 were not ready to accept Mendel's new IDEAS.

The case of Mendel is the classic example. All it proves is the usefulness of technical libraries, of translators, abstractors, reviewers, etc., in preventing what Dr. Ellice MacDonald, a modern biologist, calls "that crime against research, duplication of effort." It does not prove that human nature is changed when an important disclosure is made to many large circles instead of to one small circle. It does not prove that the mere EXISTENCE of modern publicity facilities can make any great NEW idea—any great new IDEA—penetrate human skulls faster or more easily: the greatness of an idea is seldom perceived by those who manage or make use of the public-opinion industry.

Here, then, is why the title of this editorial is interrogatory instead of declaratory. Here, then, is why either yes or no is the right answer:

Certainly, the IDEAS to be disclosed during Instrumentation Week will have the potential ability of ushering in a new era. Probably, they will cause it slowly to emerge—no trigger effect!

Possibly, the new era will not be recognized as such until these ideas permeate the world of technology from the printed page to the production line, until they find expressions in newer and more improved methods, in still better things and still better ways of living.

Before these results of the 1946 Instrumentation Week are fully felt, the ISA's 1947 Conference in Chicago will be over; and *its* ideas will be fermenting another new era in Instrumentation. The ISA's 1948 Conference will likewise . . . Yes, but bear in mind that the new era OF Instrumentation is already here. Specifically, the grimy Age of Machinery which was not free from evils has already given way to the Age of Instrumentation which is making Technology a pure blessing. —MFB

*Johann Gregor Mendel, the Austrian monk who in 1865 announced his discovery of two of the mathematical laws of heredity but did not call them such and did not know (no one knew) their universal applicability and their importance in mammalian breeding. From 1819 to 1861, prizes had been offered for solutions of problems of pollenization, etc., in agriculture (and incidentally in floriculture, horticulture, silviculture, etc). Mendel's paper, *in an Austrian horticultural journal*, got little notice among the thousands written in that period.

Diaphragm Control Valves*

By BRUCE IRWIN, Hammel-Dahl Co., Providence, R. I.

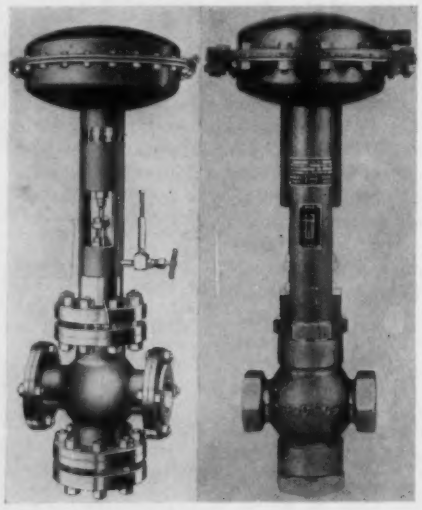
MANY control specifications go into multitudinous instrument details as to range, chart drive, instrument sensitivity, accuracy of pilot output, pilot capacity, deviation from the mean, hysteresis, and so on, but they generally end up by saying, "One 4" control valve, extra-heavy cast-iron flanged body, stainless steel trim." Regardless of how well the instrument can measure the condition to be controlled, unless the control valve does exactly what the instrument commands, you have an unsatisfactory control installation. Let us, therefore, examine this thing called a diaphragm control valve to see (1) what it is, (2) how it functions mechanically, (3) what we mean by valve characteristic.

Basically, a diaphragm control valve is a means of introducing a variable resistance into a fluid flow system. Under low flow conditions, the control valve must dissipate energy in the form of pressure drop across the valve plug to permit the desired flow rate. When high flow rates are demanded, little energy is dissipated. The variation in energy absorbed by the control valve is governed by its ability to vary port area. A definition of a control valve might then be "The means of introducing variable resistance into a fluid flow system" or, as Ed Dahl facetiously classifies it, "An engineered obstruction in a pipe line."

Actually, mechanically, most control valves consist of a valve body with a valve plug and stem attached to a diaphragm. The diaphragm is enclosed in a diaphragm case generally mounted on a spring barrel. Air loading on the diaphragm is balanced by some external force, generally springs. Variation in air loading pressure from the control instrument will cause the diaphragm to move. As this is connected to the valve plug, the valve plug will assume variable positions in relation to the seat of the valve body. For this reason, I might define a control valve as a "Diaphragm-operated Variable Orifice." As most of our discussion this evening will relate to control of fluid flow, I should like to use this simile of calling a diaphragm control valve a "Diaphragm-operated Variable Orifice," being careful to point out that an orifice need not be circular in cross section. Slide No. 1 shows at the left a flanged-end control valve with through-bolted bonnet and blind flange; and at the right a screwed-end valve.

For the purpose of clarification, I should like to mention the more common types of construction of control valves, merely to define the term for purposes of discussion. Any mention of the term "control valve" may be considered to refer to any of these diaphragm-operated valves: (a) Single-seated, such as piston, needle, wedge, or step cone; (b) Double-seated, or balanced, such as parabolic, V-port or annular type; (c) Free-flow Venturi throat; (d) Pressure-balanced; (e) Three-way; (f) Butterfly 30°, 60°, 90° and V-port; and (g) Saunders Patent (Hills-McCanna).

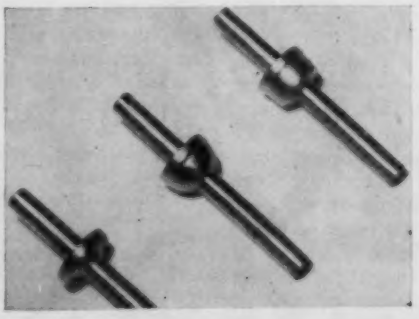
There are two basic types of control valve action: "air-to-open" and "air-to-close." In former years, the terms "direct-acting" and "reverse-acting" were used but, owing to diametrically opposite use by various manufacturers, these terms have been largely dropped. In most cases, the préssure variation applied to the diaphragm to stroke the valve completely is normally 0-15 lbs./in.^{2}, although practically, it will run about 2-14 lbs./in.^{2} to insure: (1) definite spring closing in the air-to-open type; and (2) that the 15-lb. output of the controller will tightly close or completely open the valve.



Slide 1

Actually, the spring range of the diaphragm control valve must match the instrument pilot range.

While the more usual range of valve loading is 0-15 lbs./in.^{2}, some manufacturers use a 0-25 lbs./in.^{2} range. Regardless of the pressure range, the diaphragm valve is supposed to position the valve plug in a definite reproducible position for a given loading pressure sent from the control instrument. It also should respond to the most minute change in output pressure from the control instrument.



Slide 2

Let us assume that we have a perfect diaphragm superstructure and a frictionless stuffing box on the valve body. Based on this assumption, the most important factor of control valves left to discuss is "Control Valve Characteristics," which is the subject of this talk. In general, the three most common valve characteristics are: (a) *Quick-opening;* (b) *Linear;* and (c) *Equal percentage or logarithmic.* Slide 2 illustrates each of these constructions in solid plugs, which operate on an annular basis, although the same characteristics could be equally well produced by a V-port plug or several other types of construction.

The question of control valve characteristic, briefly stated, is, simply, "How does the valve act?" In the beginning, control valves were made with quick-opening or bevel-seated valve plugs, single or, preferably, double-seated. The lift in these valves was generally ¼ D, D being the seat diameter. Valve lift was arrived at by dividing the seat areas $\pi D^2/4$ by the seat perimeter πD, giving the maximum useful lift of $D/4$. The flow curve generated is a straight line at constant pressure drop through most of the travel.

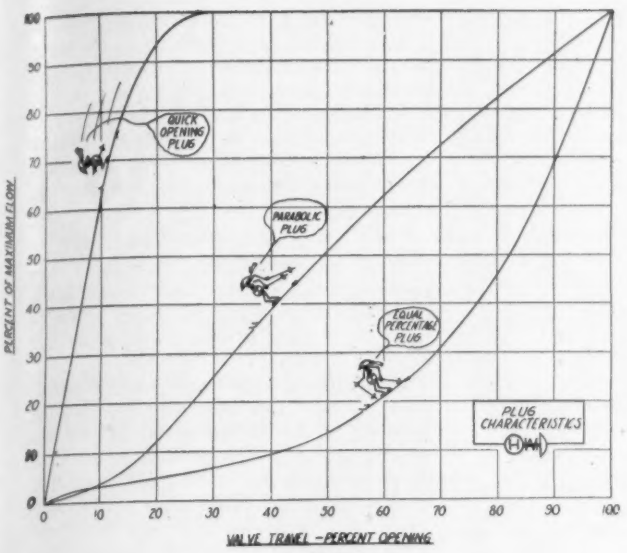
As long as thirty years ago, it appeared easier to control flow by increasing valve lift. Consequently, a double-seated skirted type plug with four equilateral triangular ports in each skirt was manufactured. While the word "V-port" describes the construction accurately, the valve port area as a lift relationship actually produces a parabolic curve. The lift is generally several times that of bevel-seated plugs.

Approximately fifteen years ago, the solid-type parabolic plug was introduced. The plug contour and flow behavior produced at that time can be accurately described as parabolic. The lift of this valve was several times that of a bevel-seated plug, but generally less than a V-port.

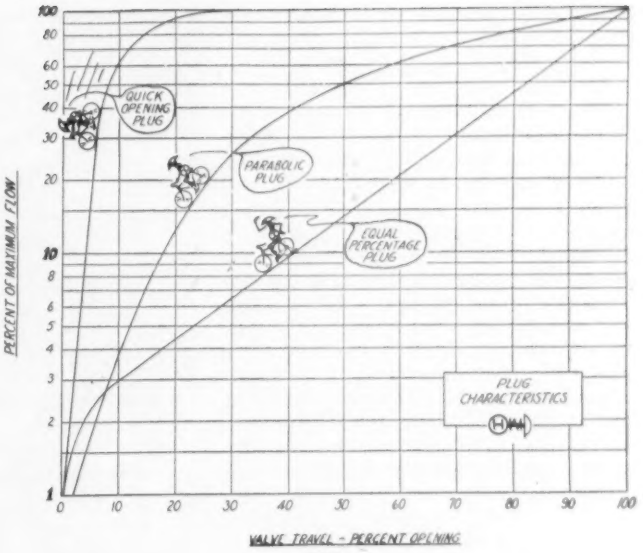
Present-day thinking has swung to a large extent from the parabolic-type flow curve to the equal-percentage flow curve. The term "equal-percentage" is used quite commonly when speaking of control valve flow characteristics. Unfortunately, however, there have been many varieties of definitions for this characteristic and there is a great deal of confusion as to its basic advantages.

An important function of the equal-percentage valve is its consistent behavior under conditions of varying flow

*Presented at the Spring Meeting of the Instrument Society of America, Detroit, Mich., April 4, 1946.



Slide 3



Slide 4

and pressure drop. This may be traced directly to the equal-percentage flow characteristic. Because of this fact, a brief description is included, covering in simple outline the fundamental reasoning underlying this important concept.

Consider the following definition carefully:

A valve having an equal-percentage flow characteristic will produce a change in flow, for a unit change in lift, which is proportional to the quantity flowing just before the change is made.

When the flow is small, the change in flow is small. When the flow is large, the change in flow is large, for the same increment in valve lift. The change is proportional to the quantity flowing.

I should now like to show you some slides illustrating the flow characteristics of the various valve plugs mentioned before, inasmuch as you have already seen the physical appearance of the valve plugs which produce them.

Slide 3 is a characteristic plot on uniform coördinates of a quick-opening plug, a parabolic or linear plug, and an equal-percentage valve plug. You will note that the quick-opening plug generates a straight line for about 70% flow and that the valve travel is only 30% of the other types. This type of plug is satisfactory with constant pressure drops or on open-and-shut service. The parabolic or linear valve plug gives about 50% capacity at 50% opening. The equal-percentage plug gives about 13% to 15% capacity at 50% lift or opening. I should point out again that the actual lift in inches of the parabolic and equal-percentage curves is several times that of the linear plug.

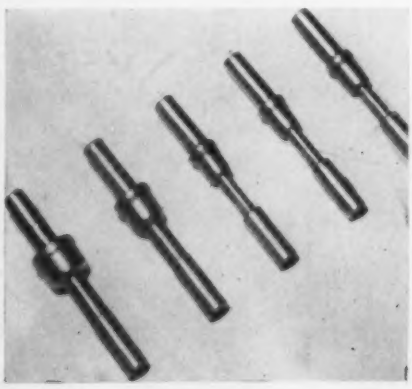
Slide 4 shows exactly the same information as Slide 3, but plotted on semi-logarithmic paper with the flow scale divided into two sections (called "cycles"), one covering a range from 1% to 10%, the second from 10% to 100%. This type of graph, like a slide rule, gives the same percentage accuracy regardless of the magnitude of the number. Several advantages are gained by this type of plotting:

(1) Equal-percentage curves plot as a straight line or a constant rate of change.
(2) The steepness of the line indicates the rate of change of flow.
(3) For 1% change in lift, the percentage plug port gives a 4% change in flow.
(4) Rangeability, or ratio of maximum to minimum controllable flow, is clearly shown.
(5) Also shown is that the parabolic or linear curve is actually a square-root curve with a varying rate of flow for different lifts.
(6) The quick-opening plug still generates a straight line, but only over a very limited valve travel or percentage opening.

The information, however, is still entirely qualitative.

In order to present valve characteristics in terms of actual lift and actual flow units, the idea of a valve coefficient (C_V) for control valves was conceived. The valve coefficient is to the control valve as the orifice meter coefficient is to orifice meter flow measurement.

Let us briefly review Webster's definition of the word "coefficient": "Any constant quantity or number placed as a multiplier before an unknown or a variable quantity of an expression containing one." An example familiar to all of you is the practical orifice meter formula for liquids, $Q = C\sqrt{h}$.



Slide 5

Q = Liquid in g.p.h. at 60°F.

C = The coefficient or quantity of liquid flowing through the orifice when there is 1" of water differential.

h = Differential in inches of water.

This formula is exactly the tool we want for valve work, but the units are not suitable. Convenient units for the flow coefficient of a control valve are gallons per minute and pounds per square inch pressure drop. Using water and a constant unit pressure drop of 1 lb./in.^{2}, the resultant flow at any valve lift is designated as flow coefficient (C_V).

The basic value of C_V is the same for liquids, gas and steam. If the flow conditions are known on either liquid, gas, or steam, the flow coefficient C_V can be computed directly by means of formulas which will be stated subsequently. If, for example, C_V was determined from a set of conditions on steam service, it can be used to determine capacity on either liquid or gas. The valve coefficient with the plug at maximum lift (valve fully open) accurately expresses the actual port area of the valve and is a number which can be used to state the valve's capacity.

A control valve which has a maximum C_V of 10 is one with port area which will pass 10 g.p.m. of water at 1 lb./in.^{2} drop. This happens to be a 1" control valve. The numerical value of C_V simply expresses the number of gallons per minute flow which would result for 1-lb./in.^{2} pressure drop. As control valves are built in rational sizes above 1", $C_{V\max}$ for a 2" valve would be $2^2 \times 10 = 40$; for a 4" valve, $4^2 \times 10 = 160$; for a 10" valve, $10^2 \times 10 = 1000$.

Slide 5 illustrates the constructional features of a family of five equal-percentage annular plugs, which have consistent flow behavior. Their principal features are: (a) A series of angular cuts on a piston plug which can be reproduced in any instrument shop in an emergency; (b) common seat-ring,

O.D.; (c) two seat sizes only, which require only a plug and stem change to change capacity; (d) high lift (½" in all sizes); (e) related maximum flow capacities; (f) reversibility from air-to-open to air-to-close action by reversing valve body; (g) tight shut-off; and (h) top and bottom guiding.

Slide 6 plots valve lift in inches versus C_V—Flow coefficient of the family of quintuplets shown on Slide 5. We now have quantitative information and a definitely more useful type of curve than either Slide 3 or Slide 4. In addition to the information given by Slide 4, we find the following: (a) The relative capacity of the various valves; (b) the ability to calculate accurately valve lift in inches at intermediate and low flows; and (c) a means of numerically expressing actual valve capacity.

Let us assume we have selected a ½" valve with a C_V of 4 as being suitable for maximum flow conditions, but wish to see what it will do at minimum flow conditions, namely 1 g.p.m. of water at 25-lb. pressure drop. The C_V calculates $\sqrt{(1/25)}$ or 1/5 or 0.2. You will note a ½" valve will have a lift of 0.12" at this flow rate.

Slide 7 plots the percentage of maximum lift versus C_V for double-seated percentage plugs in sizes 1" through 12". These curves will permit the same type of analysis as mentioned for the equal-percentage annular plugs. In sizes 6" and over, a skirt-type valve plug which produces the same flow characteristic can be used. When the valve lift is known, it is possible to calculate the valve capacity at any point of valve travel.

Slide 8 illustrates the equal-percentage annular plug used to produce the curves shown on Slide 7. This solid type plug is usually made from a drop forging, using a forming tool for machining. It can also be fabricated from bar stock and machined in the field. Its shape is such that no material can stick to its surface. It has a great many strong adherents in the chemical and petroleum industry. The best way to insure accuracy of contour is to use an optical comparator, as illustrated on Slide 9.

I will now list the basic flow formulas to determine valve capacity with C_V and the flowing conditions given:

LIQUID:

$$\text{G.p.m.} = C_V\sqrt{(p/G)}$$

STEAM:

$$W = 63C_V\sqrt{(p/V)}$$

GAS:

$$Q = 1360C_V\sqrt{[(pP)/(460 + {}^\circ\text{F.})G]}$$

$$W = 104C_V\sqrt{[(pPG)/(460 + {}^\circ\text{F.})]}$$

where:

C_V = Flow coefficient of valve
d = Valve size in inches
°F. = Inlet gas temperature
G = Specific gravity
G.p.m. = Gallons per minute
P = Inlet pressure in lbs./in.² absolute
p = Pressure drop across valve in lbs./in.² for steam or gas not greater than $P/2$
Q = Cubic feet per hour at 60°F. and 14.7 lbs./in.² absolute
V = Specific volume of inlet steam
W = Pounds per hour

FLOW COEFFICIENT

d	C_V
3/16	1.0
¼	1.6
⅜	2.5
½	4.0
¾	6.3
1	10
1¼	16
1½	25
2	40
2½	63
3	100
4	160
6	360
8	640
10	1000
12	1440

When p, the pressure drop across the valve for steam or gas, becomes less than one-half the inlet absolute pressure P, any reduction in outlet pressure below ½ of the absolute inlet pressure will give no further increase in flow. This is known as critical flow. All compressible fluids follow this law approximately.

If all the liquid flowing conditions are known, and it is desired to determine C_V and a definite valve size, the above liquid formula may be written as follows:

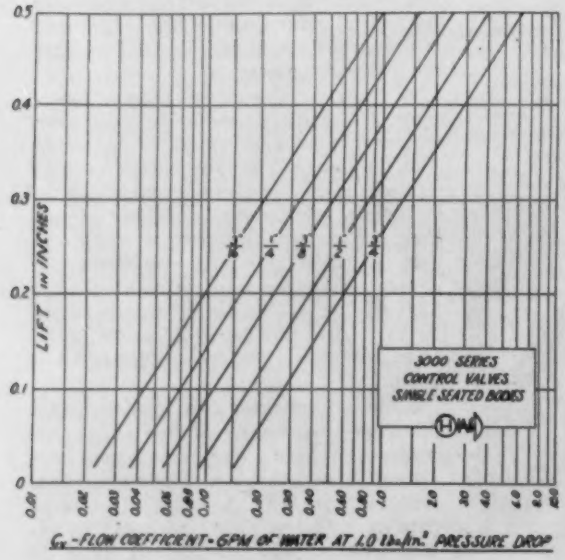
$$C_V = \text{G.p.m.}\sqrt{(G/p)}$$

With gas and steam similarly expressed, when C_V has been determined, it is only necessary to select a valve with a C_V equal to or greater than the calculated value.

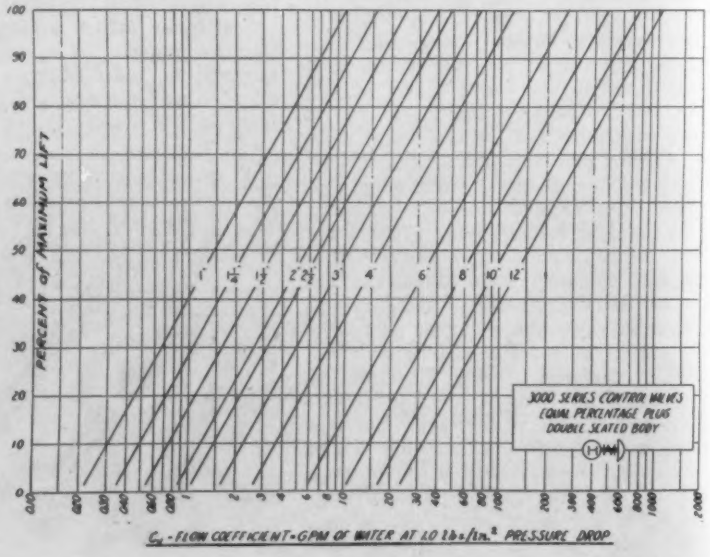
If a definite size valve with a maximum C_V has been selected, and it is of interest to determine valve lift at intermediate or minimum flow rates, it is only necessary to calculate the C_V for these conditions. The actual percentage lift or lift in inches can then be determined by reference to the proper flow curve, shown on Slide 7. For example, a 1" valve has a C_V maximum of 10. Now, if the flow of water is 1 g.p.m. and the pressure drop is 9 lbs./in.², can the valve handle this condition and, if so, what is the lift? C_V calculated 0.33. By referring to Slide 7, you will see we have 11% lift.

A much simpler, quite accurate, and much more rapid way of determining valve size is to use a capacity chart. Slide 10 gives the capacity of the family of five extremely small plugs used in pilot plant work. These latter carry no line size, as there is nothing to express size. No. 5 plug, for example, has a maximum capacity of 2.3 g.p.m. at 500-lb. pressure.

Slide 11 illustrates flow capacity from a 3/16" valve plug ($C_V = 1.0$) to a 12" valve with a capacity ($C_V = 1440$). The chart is easy to read. For example, let us assume the flow rate of 150 g.p.m. of water at 25-lb. pressure drop. We merely have to follow the 150-lb./in.² line horizontally until it intersects with the vertical 25-lb. pressure drop line. You will note this point is above a 1½" size and below a 2" size. We would,


LIFT in INCHES
3000 SERIES
CONTROL VALVES
SINGLE SEATED BODIES
C_V - FLOW COEFFICIENT - GPM OF WATER AT 1.0 lbs/in.² PRESSURE DROP

Slide 6


PERCENT of MAXIMUM LIFT
3000 SERIES CONTROL VALVES
EQUAL PERCENTAGE PLUG
DOUBLE SEATED BODY
C_V - FLOW COEFFICIENT - GPM OF WATER AT 1.0 lbs/in.² PRESSURE DROP

Slide 7

therefore, select a 2″ size valve. Specific gravity correction can be made by using the specific gravity curve shown at either the left- or right-hand side of the chart. By inspection of this chart it is possible to read the capacity of valve sizes up to pressure drops of 800 lbs./in.^{2}. Slide 11 also illustrates engineered design. You will note the valve coefficients: starting at 3/16″, they are 1.0, 1.6, 2.5, 4.0, 6.3, as size increases to ¾″. Starting with the 1″ valve, we have a series similar but ten times larger; namely, 10, 16, 25, 40 and 63 through the 2½″ size. These are ASA Preferred Numbers, each number being 60% greater than the preceding number. Simply stated, a mathematical series of this sort gives uniform steps. This happens to be a 60% series. Such series are used in the design of the capacity of motors, pumps, or refrigerators, so there is a sensible size relationship. You will notice that this series carries on through the 4″ size valve.

My basic philosophy of control valve sizing is that a 1″ valve should have a capacity of 10 g.p.m. or a C_V of 10. Consequently, as pipe size is rational above 1″, you can mentally calculate the C_V for any size valve, merely by squaring the valve size and multiplying by 10. You will note that this calculation is true, except for the 3″ size, where we have taken the "preferred" number of 100, rather than 90. In sizes 6″ and larger, valve body size controls and the preferred number series disappears. Slide 12 shows the flow bench on which the valve characteristic and valve coefficient work was done for small sized valves 3″ and below. Slide 13 illustrates a high-pressure test set for work on pressures up to 800 lbs./in.^{2}.

These formulas and charts give a logical mathematical approach to valve selection or sizing, but there is no substitute for good engineering judgment. There is a tendency to accept the field data given as being accurate and then perform a mechanical mathematical operation. There is also a tendency to concentrate our thinking on the control valve and disregard the characteristic curve of the pump, the piping, heat exchangers or other equipment which may definitely influence the ability of our valve to control flow in the system. Let us evaluate some of these factors.

Two types of pressure drop are usually encountered:

(1) Where the initial and terminal pressure are constant regardless of flow (e.g., make-up of low-pressure exhaust steam from the high-pressure system). This type of application concentrates pressure drop at the control valve; and line friction can be disregarded.

(2) Where the control valve is in series with heat exchangers, piping, and other resistances. These other factors may influence the controllability of the system as much as the control valve does—or even more. Unless the line size is infinite, they will affect the characteristic curve of the system. Qualitatively expressed, the pressure drop available to the valve is low at high flows and high at low flows.

Slide 8

A good general rule of thumb is that at least 50% of the friction drop in the system, exclusive of the valve, should be available as pressure drop across the control valve. In other words, one-third of the total system drop is assumed to be absorbed by the control valve.

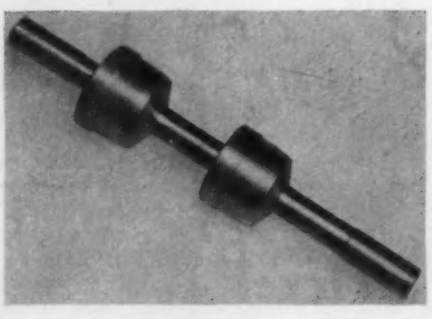
For valves installed in long or high pressure-drop lines, as on cracking heaters, the percentage drop may be reduced to 25% or even 15%. This low pressure drop, of course, arbitrarily limits the possible variation in flow.

In those cases where it is necessary to make an arbitrary choice, 10 to 25 lbs./in.^{2} may be assumed if the valve is in a reasonably short pump discharge line. If the valve works out line size, the piping system is to be suspected, and the calculations determining its size should be reviewed.

The maximum flowing quantity to be handled by the valve should not be greater than twice the normal flow rate. The maximum flow stated for valve size calculations should be based on operating data, if possible.

On all systems in Class 2 above, a reduction in flow rate means an increase in pressure drop across the control valve. If, for example, the maximum flow for the valve is 100 g.p.m. at 9-lb. pressure drop, and the minimum flow for the valve is 10 g.p.m. at 49-lb. pressure drop, the port area charge is 23:1. This is arrived at by the following calculation:

$$\frac{100}{10} \times \frac{\sqrt{49}}{\sqrt{9}} = \frac{70}{3} = \frac{23+}{1}.$$



Slide 9

The actual specific gravity of either the liquid or gas is relatively unimportant, around a value of 1.0. An error of 0.1 in specific gravity (for example by using 0.8 when 0.9 is the correct specific gravity) will cause an error of less than 5% in valve capacity. However, this error increases as specific gravity decreases.

No quantitative data are available in relation to the effect of viscosity on valve sizing. When handling extremely viscous fluids, it is the usual practice to make the valve one size larger than calculated. Further research is being carried on at present.

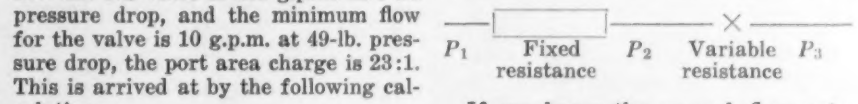
Several methods are in general use for valve selection involving vaporization:

(1) The method of making a separate calculation on the vapor and liquid volume, adding the two figures and supplying a valve with a C_V or area equal to the total figure. This method assumes total vaporization in the valve body and is generally on the large side.

(2) Select a valve one size larger than the C_V calculated on a liquid basis would indicate, and make definitely certain that the downstream piping is adequate in size. The outlet on the control valve should be increased to line size as quickly as possible. This method assumes that vaporization begins in the valve body, but reaches equilibrium at some point in the line downstream from the control valve. This latter method is most economical and generally satisfactory.

(3) The latest method is to make a heat balance.

So far, our discussion has concentrated most of our thinking on the control valve and its characteristics and has considered only in a very sketchy manner the system as a whole. Actually, our method of handling valve selection is analogous to an electrical engineer selecting a rheostat without knowing his complete circuit. Let us assume a single system in which the valve is in series with a fixed resistance which will simulate friction loss in pipe, valves, fittings, exchangers, etc.:



If we know the normal flow rate, fluid and pressures P_1, P_2 and P_3, we can calculate a line coefficient which will parallel the valve coefficient C_V. The line coefficient can be defined as the capacity of the system, exclusive of the control valve in g.p.m. of water at 1 lb./in.^{2}.

The line coefficient C_L and valve coefficient C_V can be combined in the following equation to represent the flow in the system:

$$\text{G.p.m.} = C_V \sqrt{(P_2 - P_3)} = C_L \sqrt{(P_1 - P_2)}$$

$$\text{G.p.m.} = C_V \sqrt{\{(P_1 - P_3)\,[C_L^2/(C_V^2 + C_L^2)]\}}$$

where

G.p.m. = G.p.m. of fluid

C_V = Valve coefficient

C_L = Line coefficient

P_1 = System inlet pressure lbs./in.^{2} absolute

P_3 = System outlet pressure lbs./in.^{2} absolute.

The above equation merely states mathematically that the flow through the valve is equal to the flow through the balance of the system. This equation also assumes that the only variable in the system is the position of the valve plug in the valve body. If we plot the valve coefficient C_V in logarithmic coördinates and valve lift percentage in linear coördinates, we can select values of C_V at various percentages of lift, including $C_{V max}$ or 100% lift. What the formula does is to assign mathematically the correct amount of pressure drop to the valve for any selected position of valve lift, permitting accurate calculation of flow for the percentage opening selected. Obviously, in a fluid flow system, what pressure drop is not absorbed by the valve is absorbed by the rest of the system. This is a rigorous approach, in comparison to the common practice of adding calculated pressure drops for the various system components, such as piping, fittings, heat exchange, change in pipe size, etc.

Let us assume some actual operating conditions. We can assume specifically that we have 100 lbs./in.^{2} pressure drop across our system with a normal flow rate of 100 units, which can be, for example, g.p.m. Let us assume that we can maintain the 100-lb. pressure drop under any and all conditions. Let us further assume that, at normal flow rate, the pressure drop across the control valve will be 36 lbs. and across the balance of the system 64 lbs. This ties in with my foregoing suggestion that one-third of the total system drop should be absorbed by the control valve. Let us work out the valve coefficient for a "normal" valve, and further assume that the flow curve is an equal-percentage flow curve with a 4% change in flow for each 1% change in lift, which is roughly equivalent to a valve with a 50-1 rangeability. Let us further assume that the fluid is water, to eliminate the specific gravity factor.

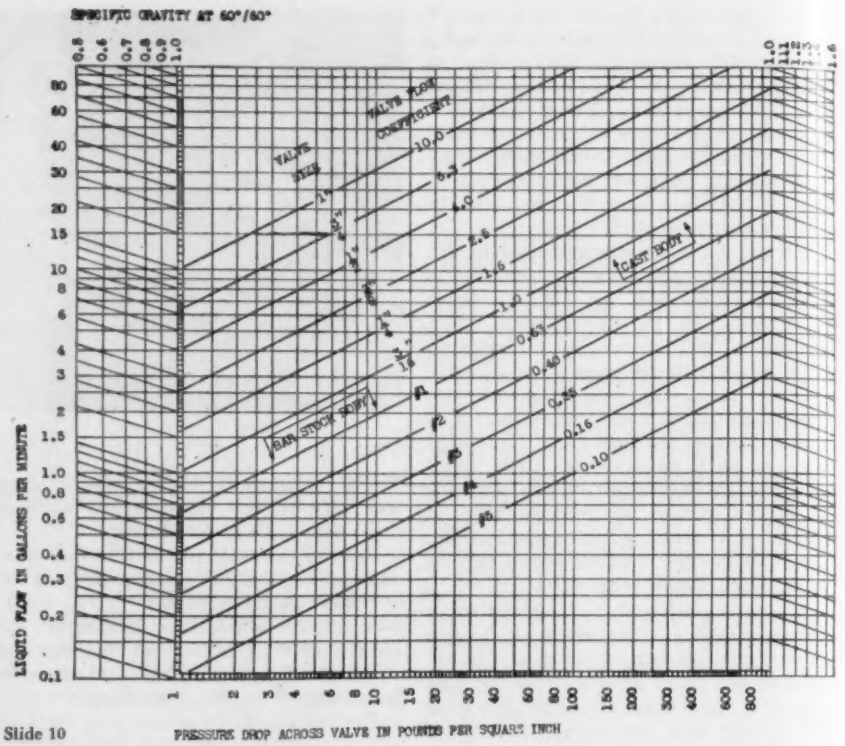
Based on the above information, let us calculate the valve coefficient C_V and the line coefficient C_L.

$$C_V = 100 \text{ g.p.m.}/\sqrt{36} = 16.7$$

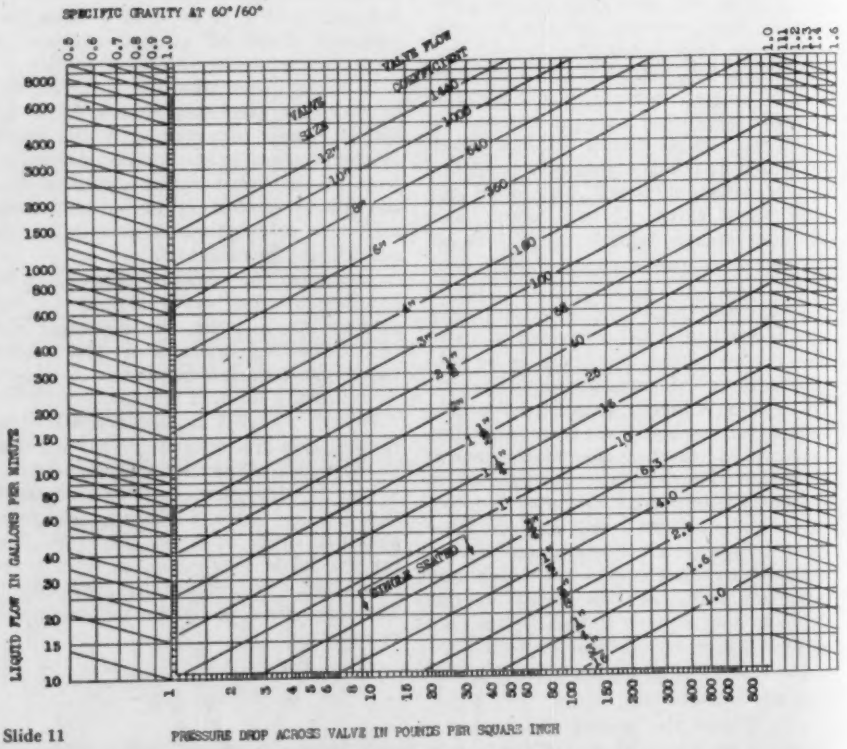
$$C_L = 100/\sqrt{64} = 12.5$$

You will note from the above calculation that the normal valve coefficient calculates 16.7 for this assumed system. If you will recall Slide 7, the $C_{V max}$ for a 1¼" valve is 16. Therefore, let us say for this system that the normal valve is practically a 1¼" valve. The line coefficient C_L is 12.5. From "Cameron's Hydraulic Data Book" or other such source, we find that a line coefficient of 12.5 is equivalent to 410 feet of 2" pipe. In addition to seeing what a 1¼" valve will do in series with 410' of 2" pipe, let us install a 1" (0.6 normal), a 1½" (1.6 normal) and a 2" (2.5 normal) valve in the same piping system. What we shall then be doing is to note the effect of valves smaller than line size up to a valve equal to line size in such a pipe system. In addition to these valves, let us include an infinitely small valve and an infinitely large valve.

It had been my original intention to plot a series of curves on semi-log paper, showing the actual flow which would occur at each point in valve lift

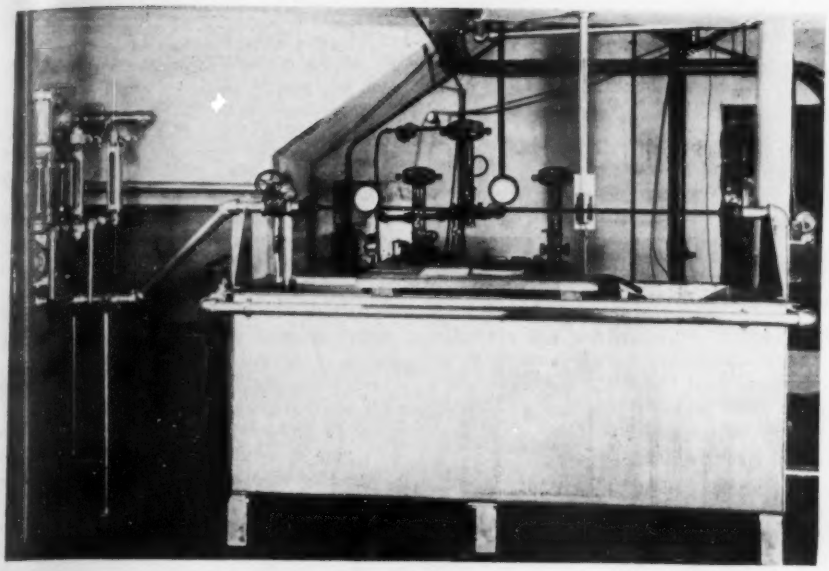

SPECIFIC GRAVITY AT 60°/60°
LIQUID FLOW IN GALLONS PER MINUTE
VALVE FLOW COEFFICIENT
VALVE SIZE
CLOSE BODY
FULL STOCK PORT
PRESSURE DROP ACROSS VALVE IN POUNDS PER SQUARE INCH

Slide 10

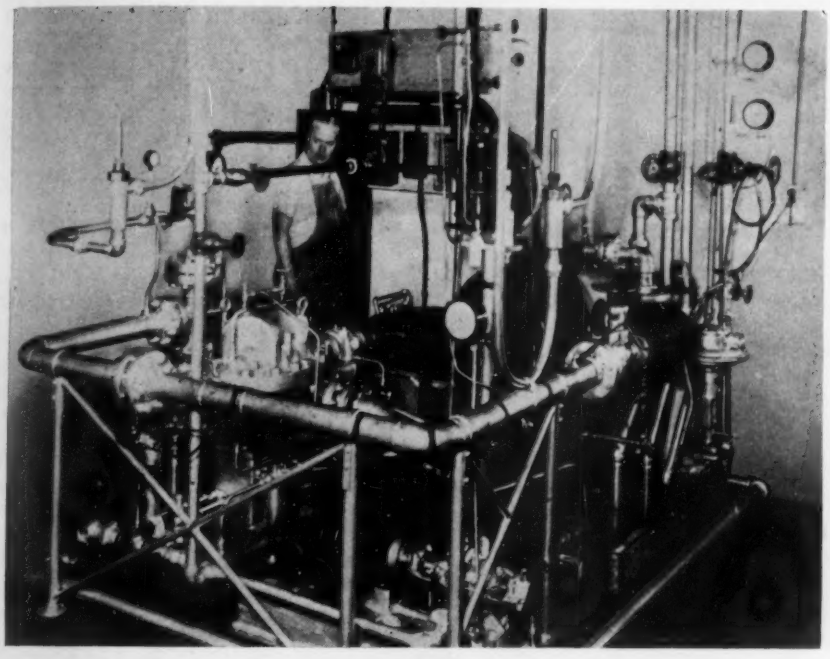

SPECIFIC GRAVITY AT 60°/60°
LIQUID FLOW IN GALLONS PER MINUTE
VALVE FLOW COEFFICIENT
VALVE SIZE
REDUCED SEATING
PRESSURE DROP ACROSS VALVE IN POUNDS PER SQUARE INCH

Slide 11

Liquid flow capacity sizing. The liquid flow capacity chart is based on water as the liquid material. To use the chart for any other liquid, the liquid flow rate must be such that the Reynolds number is greater than 4000, and liquid must not vaporize in the valve. Locate the intersection of the rate of flow in GPM and the Specific Gravity lines. Draw a line parallel to the sloping lines toward the middle of the chart to the Specific Gravity line of one. Continue on the horizontal to the intersection with the pressure drop line. The valve size line passing above this point is the required valve size.



Slide 12



Slide 13

with each of the valve sizes mentioned above in the system proposed. The only thing that would change physically would be the position of the valve plug in relation to the valve seat. I had intended calculating valve lift of 12, 20, 40, 60, 80, 90 and 100% to show the effect of line resistance on valve flow characteristics. As you can readily see, the only variable in such a system is the resistance created by the valve plug. With the method outlined previously, the actual C_V can be determined for any point in valve lift, and the actual system flow at this lift readily calculated. As stated before, the formula accurately proportions pressure drop to the valve and to the line. Therefore, the total flow in the system for any point of valve lift can be easily calculated.

In view of the fact that these curves are not available in slide form, we have calculated the conditions in the assumed system with the valve wide open, or at maximum C_V. This tabulation points out very definitely what happens with valves of various sizes in a given piping system.

Valve Size	C_V	Valve Drop lbs./in.²	C_L	Line Drop lbs./in.²	Flow G.p.m.
Inf. Small	0	100	12.5	0	0
(0.6 N) 1″....	10	61	12.5	39	78
Normal 1¼″..	16	36	12.5	64	100
(1.6 N) 1½″	25	20	12.5	80	112
(2.5 N) 2″....	40	8.8	12.5	91.2	119
Inf. Large.....	....	0	12.5	100	125

Obviously, with an infinitely small valve, pressure drop is concentrated across the control valve; the valve coefficient is zero, the line coefficient is 12.5; as there is no flow in the system, there is no line pressure drop.

The 1″ valve, which is 0.6 normal size, will have our basic valve coefficient of 10. This size valve will take 61 lbs. of the arbitrarily selected 100-lb. system pressure drop. The line coefficient of 12.5, equal to 410′ of pipe, remains constant and will absorb 39 lbs. pressure drop, permitting a maximum flow rate of 78 g.p.m., with the valve plug wide open. In other words, a 1″ valve will permit 78% system capacity.

The normal valve, or 1¼″ size, of course, was the basis on which this particular assumed system was set up and needs no discussion.

The 1.6 normal, or 1½″ valve, has a valve coefficient of 25. As the valve size has been increased, the pressure drop across the valve falls to 20 lbs., the line coefficient remains the same, at 12.5, and the pressure drop absorbed by the line increases to 80 lbs. Inasmuch as we are arbitrarily maintaining 100-lb. drop across this system, the use of a 1½″ valve will permit an increase of flow to a total of 112 g.p.m.

The use of a 2.5 normal, or 2″ valve, which is the same size as the line, gives a valve coefficient of 40. Owing to its increased size, the pressure drop across the valve falls to 8.8 lbs. We, of course, are still using 410′ of pipe, with the same line coefficient of 12.5. In view of the arbitrarily proposed pressure differential of 100 lbs. across the system, the line drop increases to 91.2 lbs.; the maximum flow in the system, using a 2″ valve in series with 2″ line, permits a total flow of 119 g.p.m.

The use of an infinitely large valve with an infinitely large C_V simply means that we have no pressure drop across the valve and are concentrating the entire 100 lbs. across the line. Under these conditions, the maximum flow possible in this system is 125 g.p.m.

What I am trying to say is simply that with a given piping system, it is not economical to attempt to increase system capacity by increasing valve size beyond the normal size. The normal size can be calculated mathematically, if necessary, but is rationally generally several sizes smaller than line size. In increasing the normal valve size to 1.6 times normal, we increase the capacity of the system 12%. By installing a 2.5 times normal valve, or line size valve, we only increase system capacity over the 1.6 times normal valve by an additional 7%, or the net increase over the normal valve of 19%. This table also shows that there is no logic in installing a valve larger than line size, as we only gain an additional 6% capacity by entirely eliminating a pressure drop across the control valve.

While this has been an arbitrarily selected system, pressure drops assigned to the valve smaller than those taken here would permit smaller increases in flow than by increasing valve size.

I believe that the possibilities in this particular subject have just been scratched. We have an extensive research program under way to verify some of the points indicated. If I may, at some future time, I would like to report to you gentlemen what we actually find in the flow test work which is now under way.

A Twelve-equation Computing Instrument*

By CLIFFORD E. BERRY and J. C. PEMBERTON, Consolidated Engineering Corp., Pasadena, Calif.

TWO new instruments which came into increasing use during the war were the mass spectrometer and the infra-red spectrophotometer. Both of these found use in the analysis of complex hydrocarbon mixtures. In this application both instruments created a demand for a third type of instrument, a computer for solving linear simultaneous equations. Since such equations occur in almost every field of engineering and physics, as well as in the applications just mentioned, the computer herein described was developed to meet these needs.

The theory of solving linear simultaneous equations is well-known; the difficulty in practice lies simply in the fact that solving equations by conventional methods requires inordinately long times. For example, using the best available techniques on mechanical calculators, an operator requires at least five hours to solve twelve equations in twelve unknowns. The same problem can be done on the new computer in about 45 minutes and by a less skilled operator.

This saving of time is of considerable importance in the field of hydrocarbon analysis, where the control of a refinery unit may depend upon the results of a mass spectrometer analysis. If an analysis indicates that a change in operating conditions is required, it is obviously desirable to know the results as soon as possible after obtaining the test sample from the unit, in order that the length of time during which the wrong conditions persist be low. Thus more accurate control over the product can be maintained.

Mathematical Principles

In order to understand the operation of the computer it is necessary to understand first the mathematical principles upon which it is based. Consider the set of equations (1):

$$\begin{aligned} 1.0\,x_1 + 0.3\,x_2 &= 0.59 \\ 0.2\,x_1 + 1.0x_2 &= 0.40 \end{aligned} \qquad (1)$$

These are two equations relating the two unknowns, x_1 and x_2. A little pencil work on this simple problem will reveal that the equations are satisfied by

$$x_1 = 0.5$$
$$x_2 = 0.3$$

A set of equations can be written in more general form as follows:

$$\begin{aligned} a_{11}\,x_1 + a_{12}x_2 + a_{13}x_3 &= m_1 \\ a_{21}\,x_1 + a_{22}x_2 + a_{23}x_3 &= m_2 \\ a_{31}\,x_1 + a_{32}x_2 + a_{33}x_3 &= m_3 \end{aligned} \qquad (2)$$

Here the a's represent the known coefficients, the x's the unknowns, and the m's known data. Obviously, any number of equations could be written in a similar manner.

The conventional method of solving such equations is to eliminate one variable at a time until only one is left, then to solve backwards, finding the value of one unknown at a time. Another less known method, however, proves to be more suitable for electrical representation. This is known as the "classical iterative method," which in more familiar terms means a method of systematic successive approximations. In this method, the first equation is solved for the first unknown, assuming arbitrary values for the other unknowns. These arbitrary values may be zero, for example, in which case the first approximation to x_1 is simply m_1/a_{11}.

Using the first approximation to x_1, the second equation is solved for the second unknown, assuming the same arbitrary values for any remaining unknowns as before. The same process is carried through for each equation, until a first approximation to each x has been obtained. These first approximations are substituted back into the first equation, and a new approximation to x_1 is obtained. Then new x_2, x_3, etc., are obtained. The process is repeated as many times as necessary until on two successive approximations the x's all remain unchanged to a sufficient degree of approximation. These x's are the correct answers.

Although this process seems clumsy on paper, actually it is extremely rapid in the computer, since each solution for an x requires merely adjusting a voltage-dividing resistor to a null, and all intermediate answers are remembered by the computer as long as they are needed. No numbers need be written down by the operator until the final answers are reached.

Basic Circuits

Referring to equations (1) or (2), it is seen that a computer which is to represent these equations must be capable of adding numbers and multiplying pairs of numbers. In Fig. 1 is shown a circuit which gives a voltage proportional to the sum of a number of voltages. It is easily found by use of Kirchoff's laws that the output voltage of this circuit is strictly proportional to the sum of the various source voltages, assuming that all of the resistors are equal and that the voltage sources have negligibly low impedances. Thus if the source voltages are made proportional to the numbers to be added, the output voltage will be proportional to the sum of those numbers.

To obtain the product of two numbers a simple circuit is used which in one form or another is familiar to most engineers. This is shown in Fig. 2, which shows one voltage-dividing re-

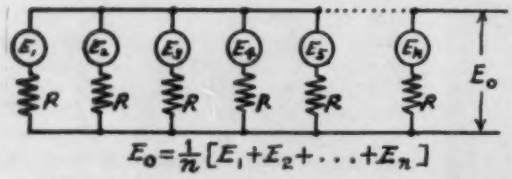


Fig. 1. An electrical network for adding a number of voltages.

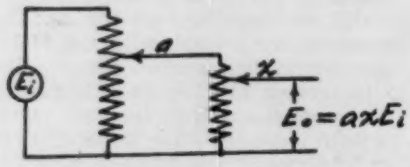


Fig. 2. An electrical circuit for multiplying two numbers.

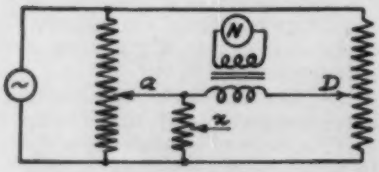


Fig. 3. A Wheatstone bridge circuit for setting a ratio on a loaded potentiometer. *D* is a standard decade.

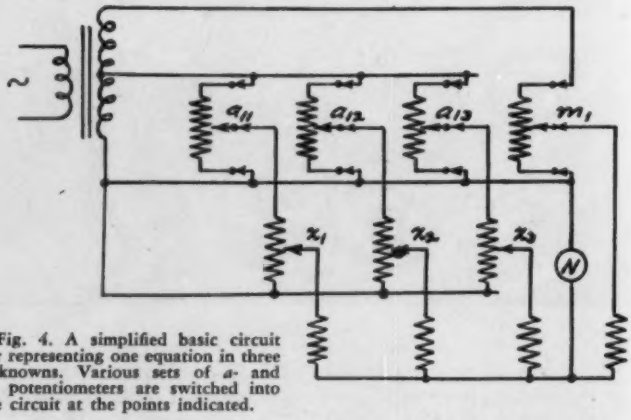


Fig. 4. A simplified basic circuit for representing one equation in three unknowns. Various sets of *a*- and *m*- potentiometers are switched into the circuit at the points indicated.

*Presented before the California Section of the Instrument Society of America, Los Angeles, Calif.

sistor (or potentiometer*) supplying voltage to a second potentiometer. The output voltage of this combination is proportional to the product of the two ratios set on the respective potentiometers. However, in setting a ratio on the first potentiometer, which we may call an a-potentiometer, account must be taken of the loading effect of the second potentiometer, which we may call an x-potentiometer.

Fig. 3 shows a circuit for setting values on an a-potentiometer. The output voltage of its arm is compared with the output voltage on the arm of a standard decade potentiometer, and when the a-setting is correct a null indicator reads a zero difference voltage. This is simply a form of Wheatstone bridge. It should be noted that the effect of the loading action of the x-potentiometer is automatically taken care of by leaving it in the circuit while the a-potentiometer is being set.

Using circuits of the two basic types just described for adding and multiplying quantities, it is simple to construct a circuit which will represent one equation; Fig. 4 is such a circuit. In this a number of a-potentiometers are connected in parallel to a source of alternating voltage. Each a-potentiometer multiplies an x-potentiometer, so that between the arm of each x-potentiometer and ground appears one of the ax product terms. All of the ax terms are added together, as required by the equation, by use of an addition circuit, which regards each one of the x-potentiometers as a voltage source. In order for the sum to be accurate it is necessary for the resistance looking into an x-potentiometer to be small compared with the addition resistor; this requirement is not difficult to meet in practice.

The m-term is regarded as a negative quantity, added algebraically to the left-hand side of the equation, and the equation set equal to zero. Electrically this involves providing a potentiometer to represent the m-term, and supplying it with a voltage opposite in phase to that supplied to the a's, as shown in Fig. 4. This potentiometer is treated in the same way as the x-potentiometers for addition.

Such a circuit is of course capable of representing only one equation. Reference to the set of equations (2) will show, however, that the same x's occur in each equation. Thus to represent a number of equations the same set of x-potentiometers and addition resistors can be used, if arrangements are made for switching different sets of a's and m's into the circuit. The appropriate switching points are indicated in Fig. 4.

In operation, the a's, which represent known data, are set on the a-potentiometers. The m's are likewise set on their potentiometers. The first set of a's, corresponding to the first equation, is switched into the circuit, and the first x-potentiometer is adjusted until the null indicator gives a zero reading. The second set of a's is then switched into the circuit in place of the first set. This time the first x is left at its previous value, and the second x is adjusted until the second equation is in balance. This process continues rapidly until all equations are in balance simultaneously. The values on the x-potentiometers then represent the values of the unknowns.

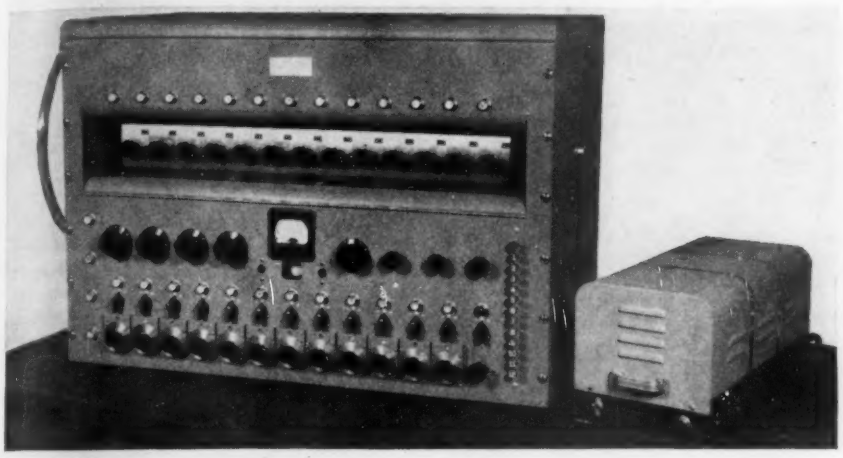


Fig. 5. Front view of computer, showing turret and all controls. The turret is rotated by means of the handwheel to bring into the window any desired row of potentiometers. The bottom row of dials are the "x-potentiometers" which represent the unknowns. The cathode-ray tube null indicator is in the center of the panel, and to the left of it are four dials of the precision decade potentiometer.

Practical Circuit Details

For purposes of discussion, the computer can conveniently be analyzed into a number of elemental parts. In addition to the basic circuits just discussed, there are the following which will be discussed in turn:

A. Selecting circuits

B. Indicating circuits

C. Signal source

D. Null amplifier and indicator

A. In order to set the desired numbers on the a-potentiometers, it is necessary first to set a number on the decade potentiometer, then to select the required a-potentiometer and adjust it to match the decade potentiometer. To select the row in which an a-value is to be set, a turret (shown in Fig. 5) which carries all of the a- and m-potentiometers must be rotated to bring the required row to the window in the cabinet. A selector switch, marked "column selector" on the photograph, then switches any one of the a's in the selected row into the bridge circuit.

A second type of selection must be performed; that is, there must be a selector for setting up the various types of circuits. A switch, called an "operation selector," on the end of the cabinet permits the following to be set up:

(a) Bridge circuit for setting a's (Fig. 3)

(b) Bridge circuit for setting m's—essentially the same as (a)

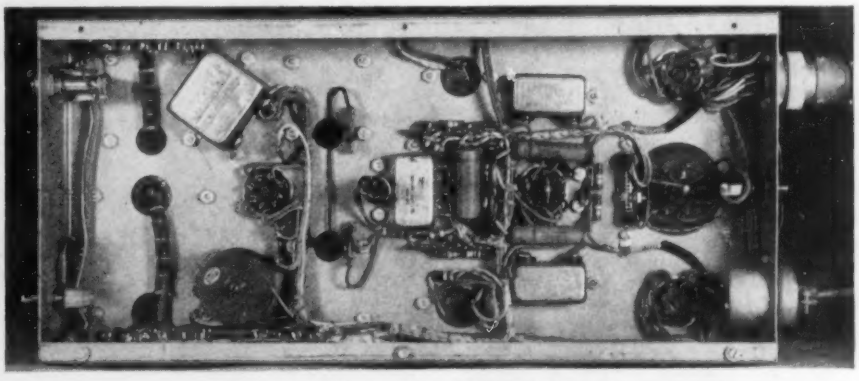


Fig. 6. Under-chassis view of the oscillator and power supply.

(c) Circuit for representing an equation (Fig. 4)

(d) Circuit for reading on decade the values of the x's found in solution.

B. A number of indicator lights are visible on the panel of the instrument in Fig. 5. These are connected with the switching circuits just described so that the potentiometer to be turned in any given operation always is one which has a light above it. The four lights in a vertical column at the left end of the computer indicate the position of the

*Editor's Note.—To save space the incorrect term "potentiometer" has not been changed to "voltage-dividing resistor" in the remainder of this article.—MFB

operation selector. The lights greatly reduce the possibility of making errors by turning the wrong potentiometer.

C. As indicated in Fig. 4, it is necessary to supply the entire circuit with a source of alternating current. Neither the actual value nor the constancy of the voltage supply is important, since the balance condition of a bridge does not depend upon the value of the source voltage. The choice of frequency is determined by several factors. First, the frequency should not be so high that stray capacitance effects are of importance. Second, the frequency should not be so low that special transformers are required. Third, frequencies near 60 cycles or its harmonics should be avoided. Taking all of these factors into consideration, a frequency of 90 cycles was finally chosen.

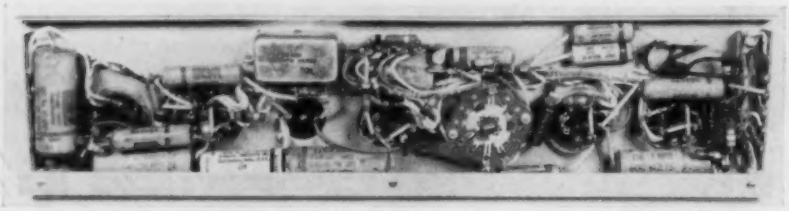


Fig. 7. Null amplifier and phase detector. This unit mounts on the front panel just above the window.

The oscillator is a conventional vacuum-tube circuit which drives a power amplifier capable of supplying 6 watts. This provides a signal voltage of about 20 volts across the a-potentiometers. It should be noted that the turret switching method allows all but one set of a-potentiometer to be out of the circuit at any time, so that only enough power to supply one row is needed. Fig. 6 shows the oscillator and power supply. This unit is not in the main cabinet, but rather in a small external case; the purpose of separation is to eliminate heat producing elements from the main cabinet as much as possible.

D. As in all bridge circuits, some sort of null indicator is necessary for determining the condition of balance for each of the operations. This takes the form of a high-gain tuned amplifier (Fig. 7), the output of which is indicated on a one-inch cathode ray tube. The indicator can be seen in the center of the panel in Fig. 5. A sinusoidal sweep from the signal source is used, so that an unbalance voltage appears as a stationary ellipse which flattens down to a horizontal line at balance. The sensitivity of the system is such that a motion of one wire out of 6000 on one of the helical potentiometers is easily discernible. Likewise, a change of one unit in the fourth decimal place of the decade can be seen.

In using such a sensitive null indicator it is obvious that a short distance on either side of null the amplifier overloads and the operator has no way of knowing in which direction the null lies. A manually-operated sensitivity switch would be one solution to the problem, but this would considerably slow the operation. Likewise a logarithmic amplifier might be made to work, but the operator would still begin turning in the wrong direction half the time on the average. Consequently a "direction indicator" was devised, consisting of a phase-sensitive detector connected to the output of the amplifier. As is well-known, the phase of the unbalance voltage of a bridge reverses in going through null. This principle is used to light either of two neon lamps, which appear at each side of the cathode-ray tube. The lights are so arranged that the operator always turns away from the light to go in the direction of null.

Precision of Components

In order to obtain the degree of accuracy required, considerable attention must be paid to the various components. The decade potentiometer, for instance, is capable of setting numbers from 0.0000 to 0.1000 with an error of ± 0.0001 or less, and numbers from 0.1000 to 1.0000 with an error of less than 0.1% of the value being set.

For all of the a's, x's, and m's, helical potentiometers are used. These permit very fine setting, since they are of the 10-turn variety and contain some 6000 turns of resistance wire. As stated before, the null indicator is capable of showing a difference of one wire, so that setting these potentiometers to the nearest wire means a setting error of only one part in 12,000.

The over-all accuracy of the computer depends largely upon the addition resistors. These resistors are padded with small resistors so that their values are within 0.01% of one another. Furthermore, each resistor is shunted by a small trimmer capacitor in order to balance its stray capacitance. These resistors are mounted in a heavy copper box which runs the length of the panel behind the x-potentiometers. Since there is no source of heat near the box, these resistors are at a uniform temperature.

Mechanical Details

The method of mounting the a- and m-potentiometers on a turret greatly reduces the panel size of the instrument and eliminates much wiring. For ease of assembly and servicing, the turret is composed of sections which are shaped like brake drums. Fig. 8 shows one section with the potentiometers in place. Each potentiometer is connected to a set of three switch contacts which engage a corresponding set of contacts mounted on a bar just below the window in the panel.

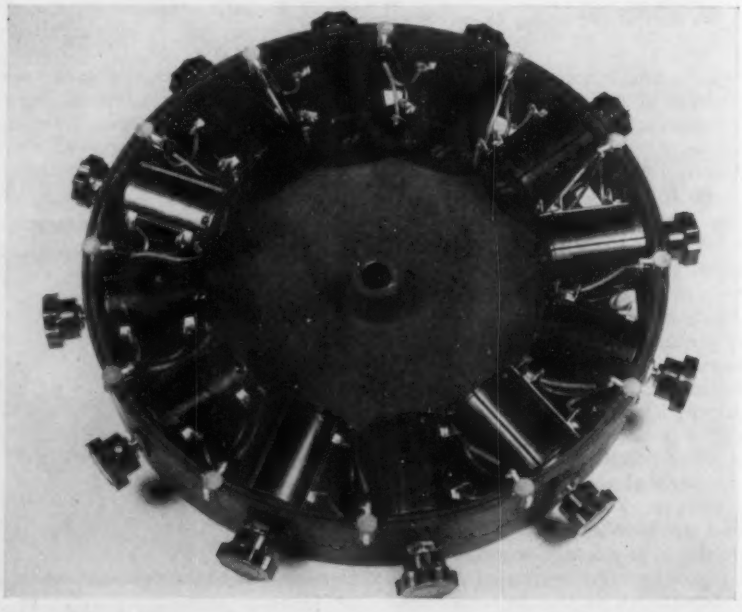


Fig. 8. One section of the turret, showing the method of mounting the helical potentiometers and contacts.

All essential parts and the wiring are carried on the front panel, so that servicing is facilitated. The cabinet is not built around a framework, but is "skin-stressed" for lightness. A single torsional stiffening tube is used between the two ends below the turret in order to prevent misalignment of the turret bearings.

'Tis Only a Pressure Controller, But—

By Q. SQUIGEL

IT doesn't work.

Yancey, the chief operator, calls to tell me it doesn't work. Yes, he calls in person instead of ringing me up on the plant phone—a sure sign of his intense displeasure. He also puts in a few pointed remarks about the instrument sales engineer, the manufacturer, myself and everyone who has anything to do with the job. When he pauses for breath after what seems like an hour of mental torture I try to tell him that it isn't my fault, that all I did was requisition the instrument. But Yancey is in no mood for wasting time on chit-chat. "Chit-chat" is when *I* talk.

The set-up is something like this: There's a column with a reboiler at the bottom, a vapor condenser, a reflux tank and pump. All the stuff goes back as reflux except about 1½% which is bled off the vapor line above the condenser as product, and another 1% of non-condensibles which is taken off the condenser. The object is to control the pressure in the column and condenser by regulating a valve in the non-condensible bleed-off line. It's only incidental that the pressure-temperature relationship at the top of the column is critical. The fact that the reflux tank has a storage capacity of only a few seconds is also unimportant. Then there are variations in the feed and in the water to the condenser, but that's irrelevant.

So I say, "Okay Yancey, I'll see what I can do about it."

Yancey winds up by reminding me of a few gruesome things that could happen to me if something isn't done.

I get in touch with the manufacturer's representative and get his shoulder wet with my tears. He's a nice guy and anyway he has his guarantee to think about. He agrees to send out a service man to fix it up.

The next day the service man calls back. "Everything's okay, chum, I put a positioner on the valve and she's smooth as four-year-old Scotch, drawing a perfect circle."

So that's that, I hope. But it isn't.

The phone rings and when I answer it, it explodes in my ear. Yancey is never in better form. Eloquently he blesses everything from pressure controllers to the UNO.

I say, "How does it act?"

"Act? It doesn't act. The pressure stays at the control point for a few minutes, then the sun goes behind a cloud, a cool breeze comes up and the pressure starts falling. And it don't come back till maybe next Monday."

"Does the valve action follow the controlled air pressure?" I ask.

"How should I know?" Yancey snorts. "All I know is the fouled-up thing don't work and somethin's gotta be done about it."

So I figure things have come to the point where I should take them up with the-guy-in-the-corner-office.

The-guy-in-the-corner-office scratches his head for a moment after I outline the details of my troubles.

"The point is this," he says, "If you expect a final control element to work, it must have hold of a larger percentage of the total flow than the maximum percentage of fluctuation."

While I am thinking that over, he pushes his fist toward me with the point of his pencil sticking out under his thumb. "Take hold of it—the pencil point," he says. I can barely get a hold on it between my thumb and forefinger. Then he pulls the pencil out of my grasp. I look at the guy with some surprise and decide that any of us are liable to crack if we stay at this process-control business long enough.

Then he explains. "The reason you couldn't hold on to the pencil was because you didn't have hold of enough of it. Do you see?"

I nod.

He continues: "The job of this controller is about as difficult as you trying to control the water pressure at the city pumping station by manipulating the valve on your kitchen sink."

He taps his pencil on the desk for a few moments to give my ivory a chance to catch up. Then he says, "If you want to correct that situation, you might try putting another control valve on the water line to the condenser. Let this controller operate both the valve in the non-condensible line and the water valve. That way you have control of the condensing rate of practically the entire flow and therefore you can control the pull which the condenser exerts on the column."

I decide that the-guy-in-the-corner-office hasn't slipped after all. It sounds to me like a good idea. I mull this idea over for a day or two until I have sufficient courage to call Yancey and suggest the change to him.

But Yancey doesn't sound like Yancey when I get him on the phone. He seems to be in good spirits. Anyway I explain to him how the application is probably wrong in the first place. I tell him about the kitchen sink and the pencil, and he says, "You better lay off that dollar-a-pint stuff, Squigel."

I ignore the remark and tell him about the additional valve that we can put on the water line to the condenser.

But Yancey says, "Change my piping again? I should say not. Once I get the plant to running smooth and you want to change it. The answer is no—*no*—NO! Anyway that pressure controller is working fine. We were getting a few slugs of water in the feed, but since we got that straightened out everything is hunkey dunkey."

That's all there is to it. I just thought I'd tell you about it while I cut out these paper dolls. But there are a couple of morals to the story. In the first place, don't pick anything up unless you can get a grip on it. And in the second place, don't always blame the instrument; the joker may be with the jerk who dreamed up the application.

Cartoon by Phil Putnam, member of Philadelphia Section, ISA. "Q. Squigel" is a member of another Section and his identity is known only to your editor.

A Moisture-control System for Aircraft Instruments Containing Vacuum-operated Gyros

By E. R. DYE and R. J. W. KOOPMAN, Cornell Aeronautical Laboratory,* Buffalo, N. Y.

DURING military operations in the CBI Theatre, aircraft flying the "Hump" met with two serious problems in the functioning of vacuum-operated gyro instruments because of the excessively moist air which was drawn into the instruments during the monsoon season. This moisture would condense on the gyro bearings and other delicate parts when they became relatively cool during overnight layovers. However, a more serious problem arose when aircraft were landed through the humid atmosphere of the monsoon season after they had made the trip over the "Hump" at high altitude and all of the instrument parts were cold. Under these conditions a considerable amount of water would be condensed and deposited in the instruments.

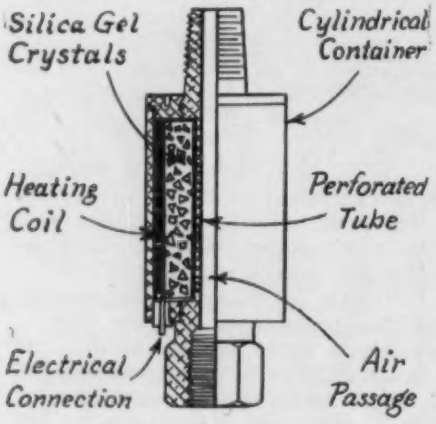


Fig. 1

These problems were referred to the Research Laboratory by Curtiss-Wright field representatives through the Engineering Department.

The first problem was solved by utilizing and improving upon the engine-pickling plug idea. A diagram of a moisture-absorbing capsule using this principle is shown in Fig. 1 and photographs of the assembled device and its components are shown in Figs. 2 and 3. It consists of a perforated tube surrounded by silica gel crystals and the whole surrounded by a heating coil. The porous tube is attached in the air intake line of a vacuum-operated instrument as near to the instrument as practical. When the instrument is not in operation, the capsule removes moisture from the still air in the instrument just as a pickling plug removes moisture from the air in an engine cylinder or crank case. When the system is in operation, the heating coil drives the moisture out of the crystals, thus reconditioning them for another absorbing period. The moisture given off by the crystals when heated passes through the instrument and is exhausted by the vacuum system. This moisture does not harmfully condense in the instrument because the air stream flowing to the instrument is increased in temperature about 15°F. for an air flow of 2 ft.^{3}/min. when the heating coil is connected to a 28.5-volt power source. This added heat in the air stream not only reduces the relative humidity of the air, but warms the instrument and reduces the probability of condensation in it. This warmth is also a factor in the solution of the problem of water condensation on descent from the altitude as will be apparent later.

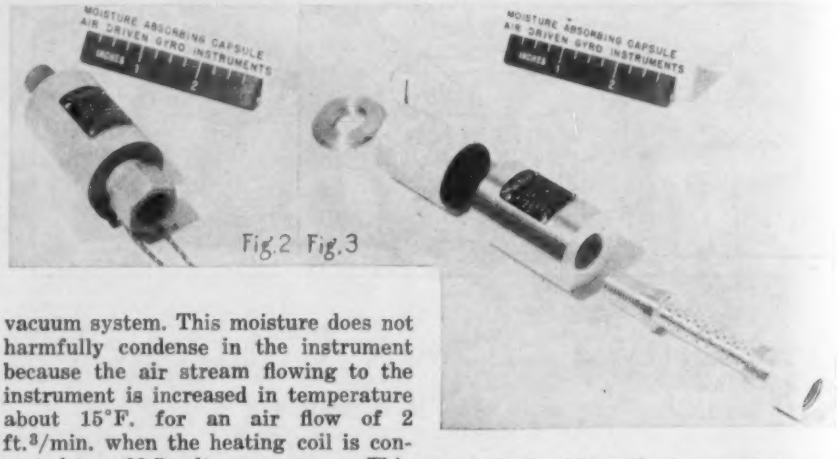


Fig. 2 Fig. 3

Another device has been constructed to alleviate water condensation on descent. See Figs. 4, 5 and 6. It consists of a water jacket surrounding a central air passage, a condensed-water reservoir and a ceramic drain plug through which the condensed water can drain when the system is not in operation. The central air passage is connected vertically in the air intake line ahead of the absorbing capsule. Its principle of operation is as follows:

When chilled as it is at the start of a descent from altitude, the water requires more time to rise in temperature than the protected instrument, thus producing a cold spot in the system on which moisture can condense before reaching the protected instrument. In laboratory tests simulating descent from altitude, it was observed that the condenser maintained a temperature differential of 10°F. below that of the instrument. The diameter of the air passage is such that the air velocity in the passage is held low enough to keep from stripping the water droplets condensing on the walls and carrying them into the instrument. A further precaution against such possible action is found in the constriction (see Fig. 4) at the top of the air passage.

Conditions simulating the operation of an instrument on descent from altitude through warm moist air were set up in the laboratory as follows:

A test instrument and the protective devices were set up in a temperature controlled cabinet, the temperature was kept constant at approximately 32°F. until equilibrium was achieved, and then increased at a rate of 2°F. per minute. Throughout the test, rated

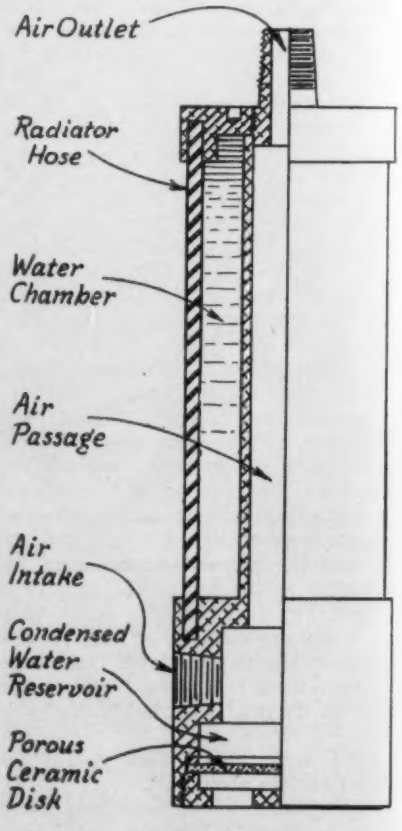


Fig. 4

*Formerly Curtiss-Wright Corporation Airplane Division Research Laboratory.

volume of air was passed through a diffuser placed under water in a heated container and thence into the protective devices and test instrument. Thus the humidity of the air was maintained at approximately 100% and its temperature at 100°F.

Fig. 5

The devices gave complete protection to a test instrument during simulated descent while similar operation without them caused the test instrument to be covered inside with droplets of water.

Both the absorbing capsule and the condenser have been tested on a transport airplane flying the "Hump" during the past monsoon season. The instruments thus protected on the aircraft came through from 130 to 150 hours of operation in perfect condition, while in the unprotected instruments on the same aircraft the pivots, ball races and balls were badly rusted.

In one of the simulated descents in the Laboratory the condenser removed 16 grams of water from the humid air. Quantitative measurements were not practical in the field, but it was observed that water dripped from the drain plug of the condenser, indicating that it was operating as designed.

When the electrical supply to the coil in the absorbing capsule is controlled by the ignition switch or other similarly-operated switch, the operation of this protective equipment is completely automatic. Field tests have shown it to be effective and practical. It can be manufactured economically.

Fig. 6

A Radio Simulator for Link Trainers

By JAMES R. GRACE, Engineer, United Air Lines, San Francisco, Calif.

WITH the advent of complex modern aircraft radio now carried aboard the commercial airliners, it is necessary to modernize the flight trainers. The Link trainers were formerly used only to instruct pilots in holding and in letdown procedures which utilized the signals from a simulated range station. The increasing use of Automatic Radio Direction Finding (ADF) equipment in orientation, in letdown procedures, and in instrument approach problems, demands that the pilots be trained in the use of this important radio aid.

Simulating the action of aircraft radio equipment becomes almost as complex as the actual radio installation. It is not feasible to have simple mechanical linkages because of the complexity of motions encountered. Movement and direction of the recorder's travel on the chart, the trainer heading, the pilot's course and his track followed, must be so coördinated that the aggregate error is less than one and one-half degrees.

General

A system of simulating the four functions of an ADF receiver was worked out by United Air Lines at San Francisco, and a working model was built in the early part of 1943. Numerous additions and improvements were added at various times. In February, 1944, three complete simulators were manufactured and were installed in the three trainers at Denver, Seattle and San Francisco. One of the Naval Air Stations became interested in duplicating this simulator. United furnished all plans, drawings, etc. to that station. During the course of construction, the Navy incorporated several innovations from which evolved an improved unit requiring less maintenance.

A simulator which incorporates all innovations and improvements gathered by United's San Francisco Radio Shop during their two years research, was built and installed in the Link trainer at San Francisco. This unit has been in use constantly and has proven

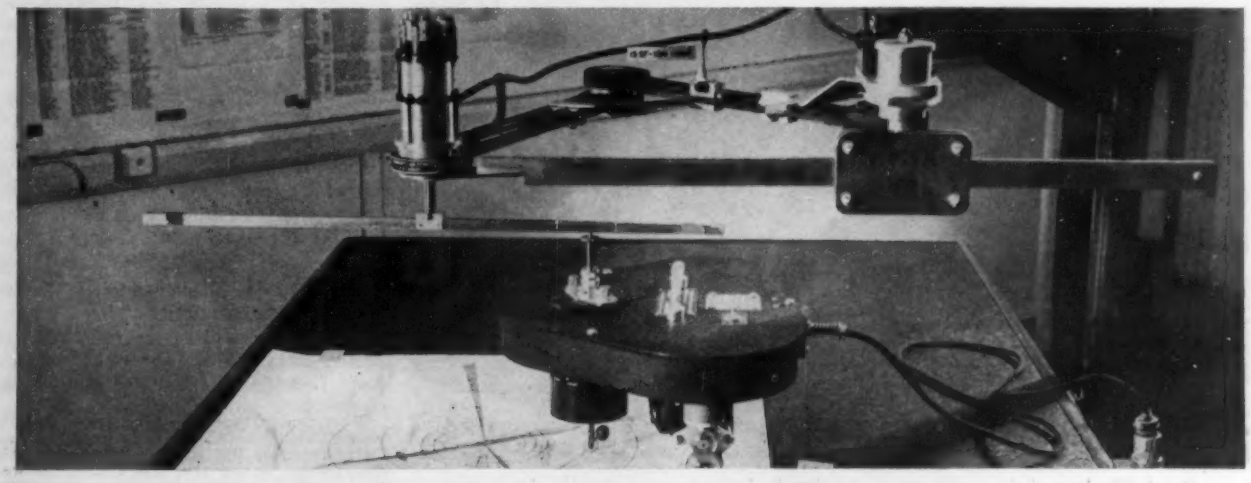


Fig. 1. Desk assembly—channel support mechanism.

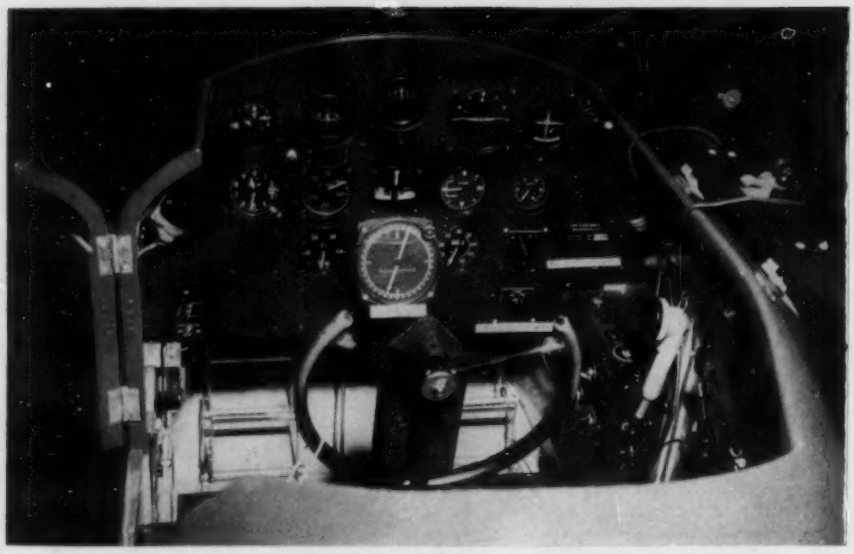


Fig 2. View looking down into cockpit showing the left-right switch, function switch and large azimuth indicator.

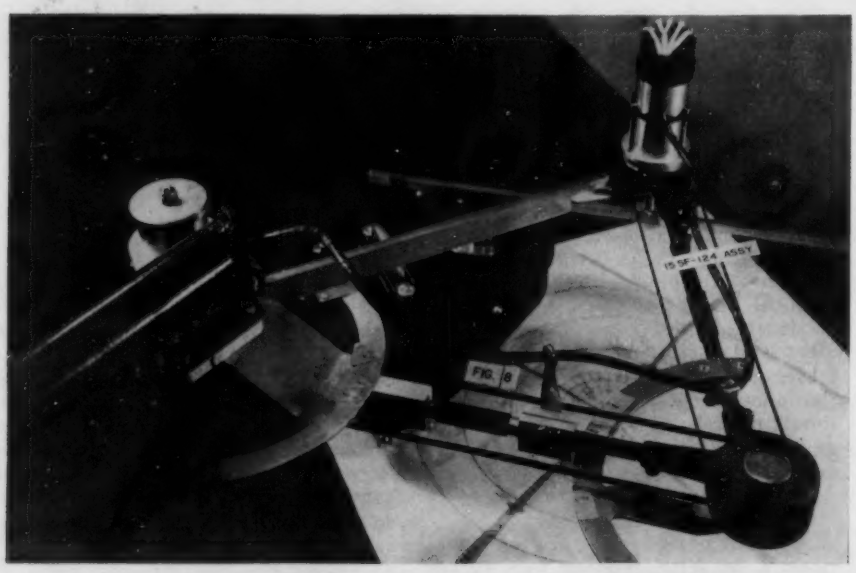


Fig. 3. Desk assembly showing the notched quadrants and wedge block detail.

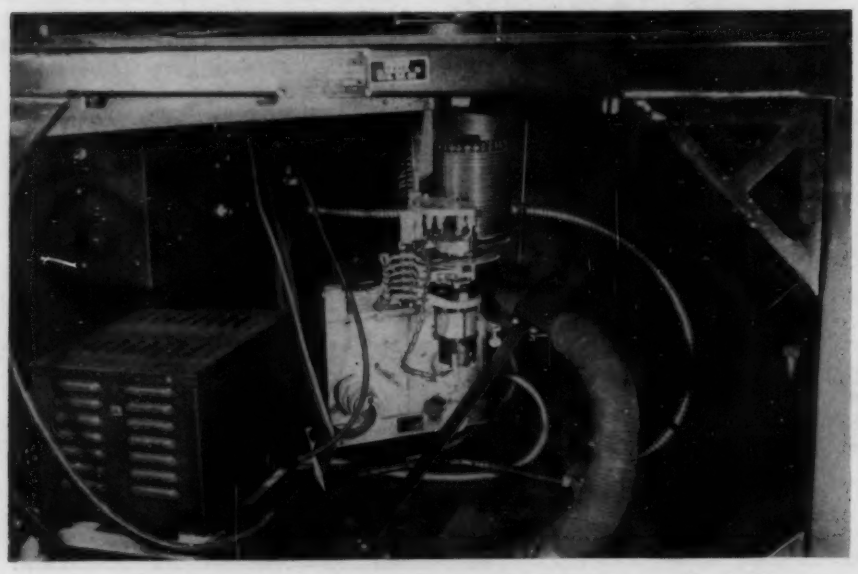


Fig. 4. The base of the trainer proper showing the base teletorque assembly already part of the Link ADF system.

highly successful. United's Engineering Report No. F-40* covers the complete engineering work and constructional details. The following paragraphs describe this simulator.

An ADF receiver when properly tuned to a radio station will indicate the direction of the station by a pointer on the azimuth indicator. The indicated direction toward the station will be accurate regardless of the wind direction or the plane's heading. This seemingly simple function of pointing to the radiofrequency source is accomplished by a specially-designated superheterodyne, a motor-driven loop and a sense antenna. The signal pick-up from the loop and sense antenna combine and feed into the receiver. The phasing of these two radiofrequency signals controls the output of the receiver. The loop position drive motor is controlled by this receiver output, and will rotate the loop until the correct null or zero loop pick-up is obtained. Any loop pick-up will then react in the receiver output to again make the motor drive the loop back into the null position. We have only to provide a remote loop position indicator in the cockpit and simply watch the needle of the azimuth indicator point in the direction of the radiofrequency source. The receiver and control circuits are combined in such a way that the loop does not have 180° ambiguity. The action of an ADF receiver has been duplicated in our simulator.

The radio simulator system consists basically of an azimuth indicator located in the lower center portion of the trainer instrument panel. (See Fig. 2.) A desk unit (Figs. 1 and 3), base unit (Fig. 4), and a fuselage unit (Fig. 5) all react to provide the pilot the azimuth of the station to which he is tuned, and to provide this bearing automatically.

Operation

A 60-cycle Teletorque motor is suspended above the chart on the operator's desk. A U-shaped channel is coupled to its armature and is rotated by a pin mounted on top of the recorder. This Teletorque actuates the cockpit indicator through a differential device consisting of two Teletorques located in the base of the trainer. In this way any movement of the recorder on the chart will give the pilot under the hood a correct bearing on the station. Angular motion of the trainer will also vary the indicator through the differential device so that the pilot's indicated bearing will still be correct.

The Teletorque which is mounted above the recorder is carried on a specially-designed support arm. In simulating the different radio stations it is necessary to place the Teletorque shaft *exactly* over the location of the

*This report runs to 23 pages, 7 diagrams (mostly highly-detailed circuit diagrams) and 9 photographs. We chose only photographic illustrations, hence the discrepancy between their number and the numerals on the photographs.—EDITOR

station on the chart. When moving this channel Teletorque to another station, its stator must not rotate about its longitudinal axis or serious error in the trainer indicator will result. Much thought was given to the design of this support arm as it is necessary for the trainer operator to relocate this Teletorque over another radio station more quickly than a pilot can retune his receiver.

The main component of the arm assembly is a standard 16″ drafting machine. The rulers have been replaced by a Teletorque mounted vertically on the head. The steel belts function to prevent any rotation of the stator when the head is moved to any position in a plane parallel to the chart. A pair of quadrants and associated spring-loaded wedges are carried on the drafting-machine arm. By simply moving the Teletorque to a position directly over the radio station, the wedges drop into notches and hold the head over this position until forcibly moved to two notches corresponding to another radio station. (See Fig. 3). A rectangular rod moving freely on six ball bearings supports the Teletorque so that it may be easily moved to any point over the chart. When the Teletorque is moved to a different position over the chart its stator will not be rotated (in much the same way that a drafting arm scale remains parallel to the drawing table regardless of where it is placed).

Another function of an ADF receiver may be simulated by setting the function switch, in the cockpit, to "manual" position. This connects in a fuselage unit (Fig. 5) which consists of 3 Teletorques and one left-right motor. In this position the pilot rotates a simulated loop with a left-right motor until a null is obtained. His indicator then points to either the station or a bearing 180° from the station. This ambiguity is normal when manually rotating any loop. This signal null is obtained by feeding the 1000-cycle audio signal into a Teletorque armature and connecting the phones across one of the field windings. In effect, this gives a rotatable transformer with two sharp distinct null positions exactly 180° apart.

Another novel feature of this circuit is the added amplifier tube placed on the control chassis. When the pilot is flying the null position, he would ordinarily get no interphone. However, by feeding the microphone into a separate electronic amplifier and then directly into the phones, interphone is obtained at all times regardless of the position of the rotatable transformer or cockpit volume control setting.

Another Teletorque indicator with rotatable azimuth is mounted in a box at the operating position and connected in parallel to the pilot's indicator. (See Fig. 6.) In this way the operator can monitor the readings being obtained in the cockpit and if necessary give the pilot off course readings from another Teletorque transmitter also mounted on the desk.

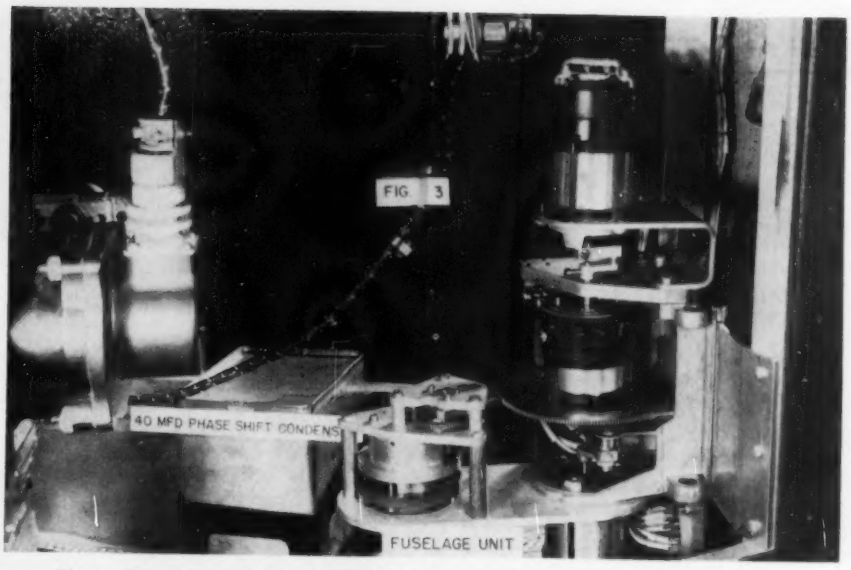


Fig. 5. This view looking in through left rear inspection door of trainer shows clearly the fuselage unit hooked onto its bracket and the phase shift condenser.

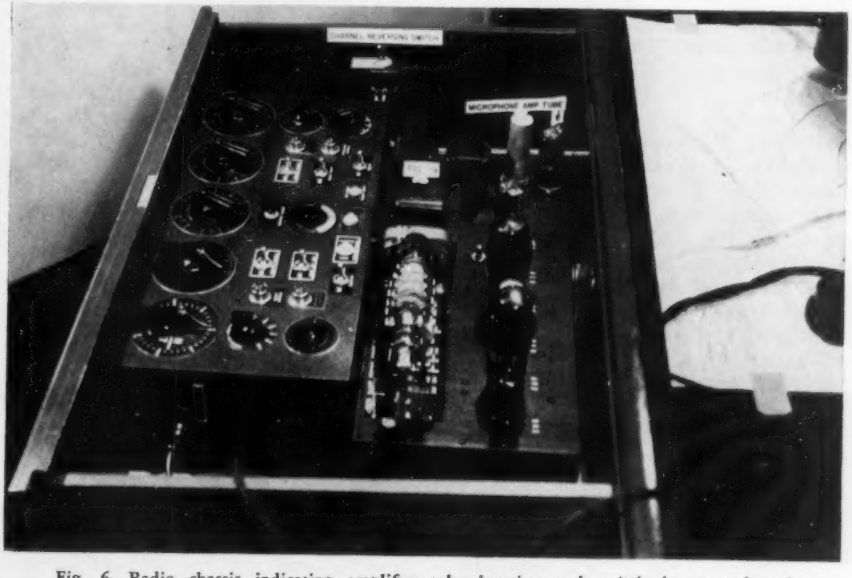


Fig. 6. Radio chassis indicating amplifier tube location and switch for reversing the channel electrically.

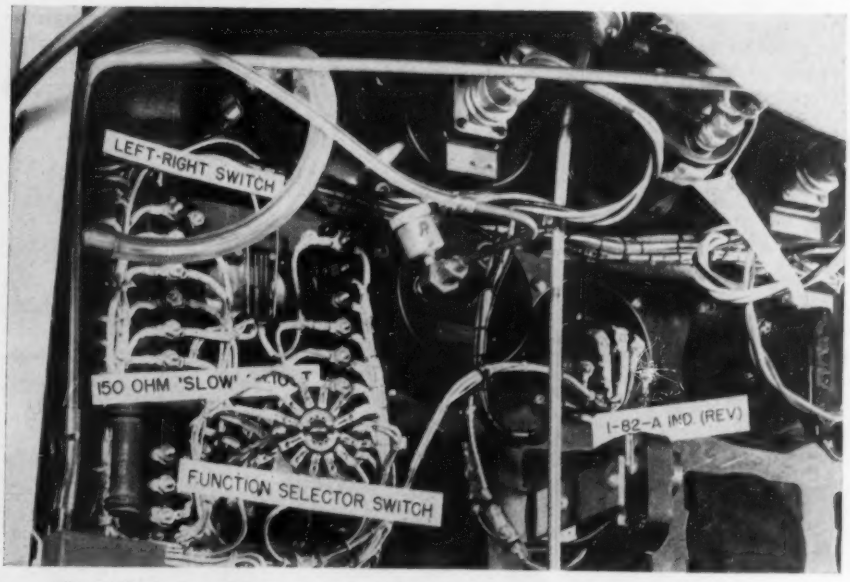


Fig. 7. Rear view of instrument panel showing the new terminal strips on each side of left-right and function switch. Note small teletorque on the 1-82-A indicator.

INSTRUMENTS ON THE MARCH

Complex Instruments Will Measure Atom Bomb's Shock Wave and Blast

[FRONT-COVER PHOTO STORY]

PITTSBURGH, Penna.—Air and water pressure shocks that will follow the explosion of two atomic bombs near Bikini Atoll in July will be measured with intricate equipment built in the Westinghouse Research Laboratories, East Pittsburgh, Pa. Capable of recording pressures far higher than those that occurred a half-mile from the Nagasaki explosion, the devices will be placed on unmanned target ships and will automatically transmit by FM radio their information to receivers on mother ships, Dr. L. W. Chubb, director of the Laboratories, disclosed in announcing the coördination by the Laboratories of all equipment and test procedures of these two phases of the forthcoming atomic bomb naval tests.

In the first test, records will be made of the air pressure exerted on two target ships by explosion of an atomic bomb several hundred feet above the surface. The second test, made during the explosion of the second atomic bomb on the water's surface, will measure the pressure created at six positions around a target ship. Program director is Dr. W. E. Shoupp, manager of the Electronics Department of the Laboratories, who was project coördinator.

Thirty-six pressure pick-ups will transmit air pressure data from eighteen positions on each of two target ships over radio channels. Signals from each pick-up on a radio channel will be examined by an electronic commutator every few millionths of a second and transmitted from each pick-up to two receivers on the mother ship.

For the second (water pressure) test, six tiny tournaline crystals sealed at the ends of rubber cables will send electrical impulses over six separate radio transmitters in a target ship. Because sound travels between three to four times as fast in water as it does in air, the impulses will be that much more rapid and transmitters and receivers must be exceedingly precise. Three cathode-ray tubes will picture the pressure curve on their fluorescent screens.

Changes that occur in a fifty-thousandth of a second are photographed by two very-high-speed cameras, which use up film at the rate of 40 feet per second.

Army's Infrared "Sniperscope" Disclosed

CHICAGO.—The unveiling of the "sniperscope," the Army's infrared telescope for seeing in the dark, reveals another top-secret example of the engineering skill and ingenuity manifested during the war in the Lincolnwood Laboratories of Bell & Howell Co. Designers and product engineers for the complete optical and mechanical unit, for tooling, and for the intricate testing equipment required, the Chicago firm made and assembled this "invisible-light" marvel for the Army's Engineer Board when comparatively few individuals in the country were aware of its nature. The power pack, an ingenious kit slung over the user's shoulder, was made (and wired to the instrument itself) by Electronics Laboratories of Indianapolis, Ind.

Infrared rays long have been recognized and used in photography. An infrared-sensitive film, for example, will record the image of a hot (but not necessarily red-hot) flat-iron in a completely darkened room.

Until the war, however, it had not been possible to omit this photographic process in utilizing infrared radiation. War-time emergency research developed a complex but practical electronic means of converting infrared reflections directly into visible images. Thus, a marksman using a sniperscope mounted on his T-3 carbine can "throw" a beam of invisible light onto his target at night and thereby identify it readily, with obvious results.

The successful operation of the sniperscope (and its companion piece, the "snooperscope," which employs the same infrared telescope with a pistol grip, for searching purposes only) resulted in the designing of an "infrared-sensitive" helmet for use by drivers and passengers in military vehicles during blackouts. Invisible light is afforded by an infrared spotlight mounted on the front of the vehicle.

Ray Nerhus, Bell & Howell project engineer on the sniperscope, reports having worn one of these helmets during a 45-mph. ride in an engineer Corps jeep through some hair-raising terrain one night. "The driver and I," says Nerhus, "had helmets; the boys in the back seat didn't. When we stopped right smack in front of a huge tree (which we could see plainly by infrared light) and then turned on the jeep's regular headlights, the rear-seat occupants all but jumped out of the car!"

With infrared "vision" an accomplished fact, plans already are being made to use the invention advantageously on ocean-going vessels as protection against navigational hazards when visible light is useless.

Infrared Electron Telescopes Revealed

CAMDEN, N. J.—Enemy beaches which were in total darkness to enemy observers were made clearly visible to U. S. Navy personnel during the war by infrared-sensitive electron telescopes, developed by scientists and engineers of the Radio Corporation of America, which were used with infrared floodlights and markers. By means of these small, light-weight, infrared viewing devices, the RCA Victor Division revealed as the Navy lifted restrictions on this secretly coded "Nan" equipment, "invisible" landing boats were put ashore on enemy territory, and beachheads were established by "invisible" men.

Heart of the infrared electron telescope is a small image tube, utilizing many television principles, having a

photosensitive surface, but especially sensitive to infrared radiation. Begun as an outgrowth of research on television camera tubes utilizing visible light, and further developed under an NDRC contract, these tubes were ultimately designed as small as 1⅝" in diameter by 4½" long.

Tens of thousands of these tubes were produced at the RCA Tube Dep't plant at Lancaster, Pa., and various types of infrared electron telescopes were manufactured at RCA Victor's Indianapolis plant, according to Meade Brunet, V-P. in charge of the RCA Engineering Products Dep't.

Basic research on the image tubes and other features of the electron telescope, as well as production of initial models, was carried out at the RCA Laboratories, in Princeton, N. J., by Dr. V. K. Zworykin and Dr. G. A. Morton, with the assistance of L. E. Flory, Dr. J. E. Reudy, and G. L. Krieger.

Production design on the image tubes was worked out by Dr. L. B. Headrick, Miss H. C. Moodey, and Dr. E. B. Janes at the Lancaster plant. Production developments and designs for the telescopes were done by R. C. Willman, R. E. Ulrich, L. T. Sachtleben, and R. B. Howard, engineers at the RCA Victor plant in Indianapolis, under the supervision of Stanley W. Cochran.

The same RCA image tubes used in electron telescopes for the Navy were also the basic element of the Army's recently-announced sniperscope and snooperscope, also developed at the RCA Laboratories under the same NDRC contract. The sniperscope was attached to a rifle and served as a gunsight as well as a means of seeing an enemy in darkness. The snooperscope enabled Army personnel to carry out short-range reconnaissance operations under security of complete visual darkness.

In 1935, RCA research experts had developed an infrared telescope which had an excellent image quality, but poor image brightness when judged by present-day standards.

By 1938 they were able to increase the infrared sensitivity from 50 to 100 times that of the original tube. These later electron telescopes could pick up a scene illuminated with a relatively weak infrared spotlight.

The 4½"-long image tube had been developed by 1942, and by the following year was in full production, it was revealed by L. W. Teegarden, Vice President in charge of the RCA Tube Department. On August 25, 1942, the various applications of infrared equipment were tested in a complete amphibious landing operation staged off Solomon's Island, Md. This and other Navy tests established the infrared electron telescope as a practical weapon of war. As sensitivity was improved, RCA tube experts and optical physicists perfected complete portable units consisting of a small spotlight and a hand-borne infrared telescope.

Operation of the RCA infrared electron telescope is not difficult to comprehend. Basically, the telescope consists of an objective lens for forming upon the sensitive cathode of the tube an infrared image of the scene being viewed, the tube itself, and eyepiece. The tube consists of a semi-transparent photosensitive cathode which is ultrasensitive to infrared radiation, an electrostatic electron lens system, and a fluorescent screen. The light-gathering objective lens system concentrates the received infrared image on the photo-cathode, releasing from the latter a pattern of electrons which conforms to the original image. An electron optical system, consisting of an electrostatic field, focuses the electron coming from the photocathode and accelerates them toward the fluorescent viewing screen where a visible reproduction of the original image is formed. The reproduced image is then viewed through a telescopic eyepiece, in the same way in which an ordinary telescope is used.

To actuate the electron image tube, a high-voltage electric power supply is necessary. Obtaining the required high voltage from a small light-weight unit powered by two ordinary flashlight cells presented special design problems. RCA engineers developed a rectified power supply using a tube, vibrator, and a transformer, which gave such excellent results that they found wide usage of this power pack in other applications as well.

Resonant-cavity Oscillators and Their Role in Radar

EAST PITTSBURGH, Penna. — Heart of a radar set is the device for generating super-high frequencies — from a few hundred million to a few thousand million cycles per second. In connection with the generation of megacycle power, two new names have joined the technical man's language— the resonant magnetron and the klystron. The basic concept of the magnetron was born in England; the klystron notion was conceived by two men working at Stanford University. To each device, Westinghouse contributed by making numerous improvements in construction and by designing for high-qauntity production.

The magnetron is the megacycle power generator, and hence is the tube commonly used in radar transmitting sets where large power outputs are desired. The magnetron at the war's beginning had the relatively weak peak output of a few kilowatts. The redesigned magnetrons can deliver up to a thousand kilowatts during the microsecond pulses.

In the magnetron, electrons are emitted from a cathode in the center of an evacuated chamber placed in the field of a strong magnet. The electrons are forced into spiral paths toward smaller, narrow-neck resonant cavities around the central chamber. When the electrons move through the electric field extending into the central chamber from the resonant cavities in the direction such that their velocity is reduced by the electric field, high-frequency power is generated in the cavities, which can be delivered to a transmission line.

Although the magnetron is a high-peak-power device, its frequency cannot be readily varied over a broad band once it has been assembled. The klystron is a high-frequency tube more easily tunable over a broad band although less peak power can be obtained from it. Electrons from a cathode are hurled through a cavity toward a reflector. A high-frequency oscillation has been established across the cavity. Hence, at one instant, the electrons are hastened in their flight by the electric field; the electrons arriving in the cavity an instant later find themselves in an electric field of reversed polarity and hence are retarded. After the electrons leave the cavity they move towards the reflector, which has a negative voltage. Before they reach the reflector they are turned back to the cavity by the reflector. In traveling towards the reflector and back to the cavity, the variation in velocity produced in the cavity results in a high-frequency electronic current, which delivers ultra-high-frequency power to the cavity.

Klystrons until recently have been able to handle maximum peak currents of the order of 50 milliamperes at 1000 volts, or about 50 watts. At an efficiency of only about 1%, this represents only one-half watt of high-frequency power. This limits the klystron to use in radar receivers where large power output is unnecessary.

It has been conventional practice in some klystrons not to permit the bunched electrons to strike the reflector. Westinghouse electronic engineers wondered what would be the effect on the power output of allowing the bunched electrons to strike a reflector coated with a secondary emitter. They took a standard reflex klystron and provided it with such a reflector. They then found that because the bunched electrons striking the reflector (primary electrons) knock from it many more bunched electrons (secondary electrons), this multiplication effect of deliver much more power, because of the high current. Furthermore, the efficiency has been about tripled. The secondary-emission klystron can absorb currents of 200 milliamperes at 2000 volts, which, at 3% efficiency, is 12 watts of usable power. This is about 24 times as much megacycle power obtainable from essentially the same tube but with a new anode. With this high-power output, klystrons which have the advantage of being readily tuned can be used as megacycle generators in low-power radar transmitters.

Scientific Glass Blowing and Laboratory Techniques

By WILLIAM E. BARR and VICTOR J. ANHORN, Gulf Research & Development Company

VIII. GLASS-TO-METAL SEALS *(Continued)*

Copper

The methods in sealing copper to glass were developed by William G. Housekeeper.[4] These glass-to-copper seals are unique because the coefficient of expansion of the glass can be considerably different from that of copper. This metal has a temperature coefficient of expansion of 162×10^{-7} per degree C., and under certain conditions it can be sealed to Pyrex which has a coefficient of expansion of 32×10^{-7}. A large surface of contact is provided between the glass and copper and the latter is so proportioned in the seal that the stresses resulting from the different coefficients of expansion are less than the ultimate strength of the joint between the glass and copper.

Four types of seals will be described.

1. Copper wire can be sealed into glass if it is flattened so that the portion which is sealed to the glass is not over 0.002″ thick. This flattened wire should be sealed by the pinch press method, but without using the preliminary thin-sleeve beading procedure because of the danger of over-oxidizing the wire. The glass of the press is first shaped by drawing down and collapsing a tube to form a shoulder and a section of tubing with a smaller diameter. The wall thickness of the shoulder and small tube should be the same as that of the original tube. The tube with the smaller diameter is cut with the burner flame. A section ½″ from the shoulder is adequate for the press seal. This short section is heated and pressed together until the opening in the pressed glass is just large enough for the flattened wire. The clean flattened wire is pre-oxidized by heating to red heat for several seconds; then it is cooled, dipped into a solution of borax and water, dried in the flame or a furnace and laid into the open press. One end of the wire should be clamped into a pin vise so that it can be held in place. The glass is then fused and pressed together to give a good seal between the glass and metal. The finished seal is illustrated in Fig. 83A. It should be noted that the seal is made on the flattened portion of the wire. The assembly is carefully annealed. The borating step is helpful in preventing over-oxidation of the copper. Vacuum-tight seals have been made without borating the copper surface, but whenever the copper comes in contact with the burner flame during the sealing operation, it has been advantageous to prevent over-oxidation by covering the copper surface with borax.

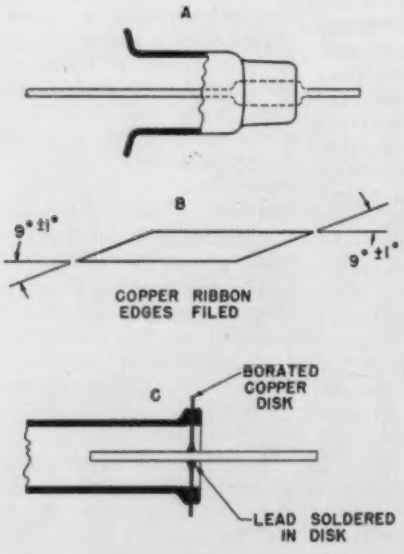


Fig. 83

2. Copper ribbon seals are made by a procedure similar to that of sealing wire to glass (in reality the flattened copper wire is a ribbon section). Copper ribbons up to 25 mm. wide and 0.015″ thick have been sealed into Corning glass 008. The ribbon seal, however, requires one additional operation which was not necessary in the wire seal. The edges of the ribbon should be filed until the two sides have angles of 9° ±1°. A cross-sectional view of the ribbon is given in Fig. 83B. This ribbon is heated to a red heat for about three seconds, borated and sealed into a prepared press.

3. Flat disks of 28 gage copper can be sealed to glass if the glass does not extend around the edge of the disk. An example of a disk seal is given in Fig. 83C. The disk is cleaned, pre-oxidized by heating for three seconds and borated. The ends of two tubes are then fused to the copper disk by holding the latter between the two tubes while the assembly is rotated in the burner flame. If only one tube is sealed to one side of the disk, it is advisable to seal a band of glass around the other. The glass on either side should not be sealed over the edge of the disk. The assembly is annealed when the seals are completed.

Vacuum-tight disk seals are quite useful if considerable current flows through the seal. Heavy copper rods which are capable of carrying currents up to 100 amperes can be brazed through the disk before the seal is made.

4. The glass-to-copper tube seal is frequently used in the laboratory. It can be used in place of a graded seal because Pyrex can be sealed to one end and soft glass to the other. The tube of Fig. 84C is a seal of glass 772 to copper to soft glass.

The glass-to-copper tube seal may be made as an external seal where the glass is sealed to the outside of the tube, Fig. 85A. In an internal seal the glass is sealed to the inside of the tube. The most successful seal is a combination of the internal and external as illustrated in Figs. 85E and 85F. All seals are made on the copper tube which has been machined to a thin or commonly-called "feather" edge. The procedure for making an internal-external seal is as follows:

1. The copper tube is machined at the end to a thin edge. It is then mounted in a glass holder. The thin edge of the copper is heated red hot in a gas-air flame and a glass tube which fits snugly over the edge is pushed over the hot end. The copper should not be allowed to cool because the copper oxide will flake. The glass is then fused to the copper without occluding air. The flame should be kept away from the metal during this operation. When the seal is finished the glass tube is cut in the burner flame about 3/16″ from the end of the copper tube as indicated by the dotted line in Fig. 85A. After the glass tube is cut, the end should appear as shown in Fig. 85B. The glass is then heated and tooled down (Fig. 85C) with a flat carbon tool. It is then tooled into the tube with a round carbon tool. The finished glass covered end should appear as illustrated in Fig. 85D. A second glass tube is then sealed to the glass covered end by the procedure outlined for butt sealing, Fig. 85E. If the tube is machined at both ends, the seals illustrated in Fig. 85F can be made. This assembly can be used for sealing Pyrex to lead glass equipment. The two different glasses can be identified by the color of the glass-to-copper seal: with lead glass, the glass-to-copper is red at the interface of metal and glass; with Pyrex it is yellow. A Pyrex-to-copper cup seal is shown in Fig. 82D. The glass-to-copper tube seals are not limited to small sizes. Many good seals have been made on copper tubing up to 6″ in diameter.

Heavy copper conductors in glass-enclosed bulbs capable of withstanding thermal shock have been quite useful for

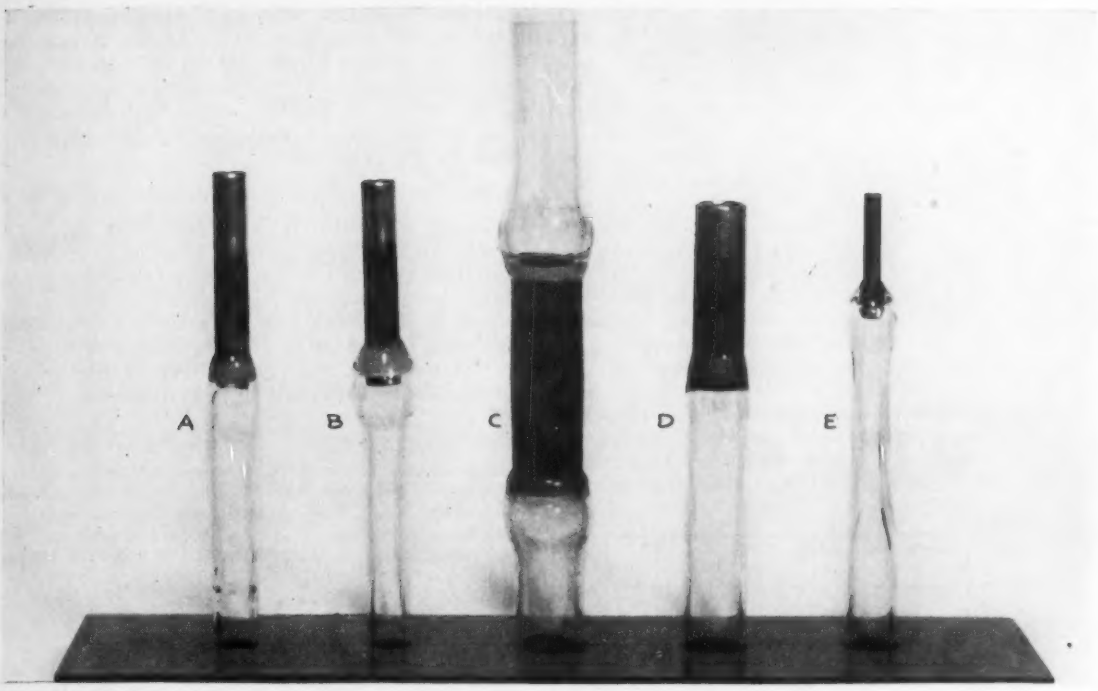


Fig. 84

the construction of ultra-high-frequency transmitting tubes. Examples of sealing a copper rod assembly to glass are illustrated in Fig. 86. The copper rod may be brazed or welded to the part which is sealed to the glass sleeve, Fig. 86A, assembled in a pressed fit, Fig. 86B, or by machined screw threads as illustrated in Fig. 86C. The glass-to-copper seal is made as follows:

1. The copper is machined to a thin or feather edge.
2. A glass tube with an outside diameter which fits snugly into the tube is flared as illustrated in Fig. 86E.
3. The copper rod is then mounted on a suitable holder and the thin edge is oxidized by heating it red hot. This is done by rotating the copper in a cross fire.
4. The flared glass is then pushed into the hot opening and the inside and outside are tooled as it is fused against the copper, Fig. 86F.

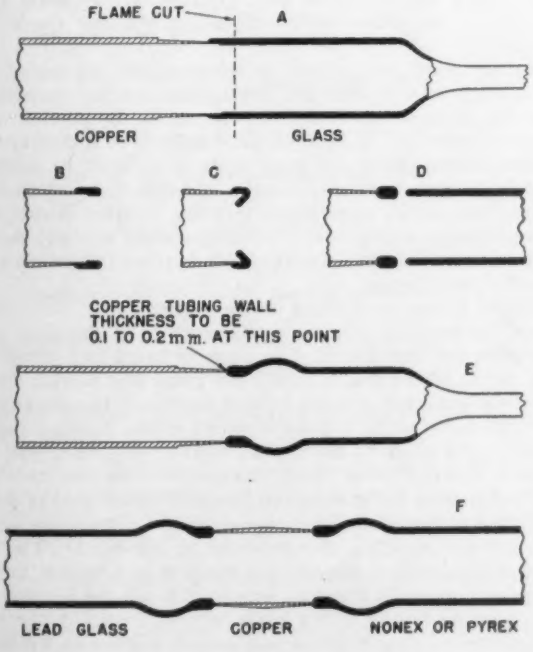


Fig. 85

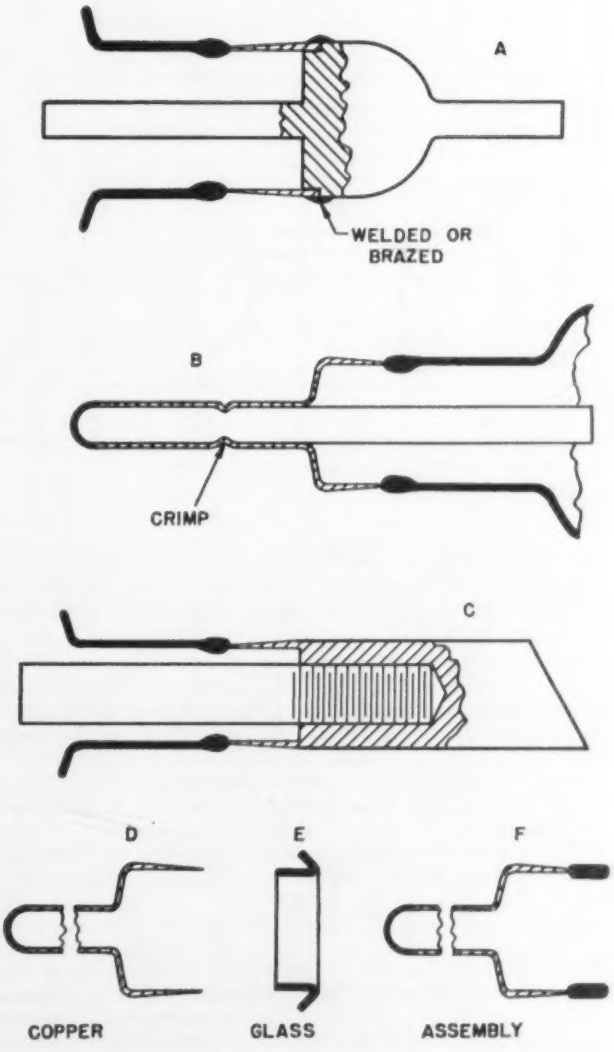


Fig. 86

5. When the glass-to-copper seal is complete, the glass is sealed to the remainder of glass tube assembly. The seals are then carefully annealed.

The glass-to-copper tube seal is mechanically weak because the copper must be thin enough to keep the stress on the glass within safe limits. The copper near the glass seal must never be overheated because it will oxidize to a degree where it will be porous. The mechanical strength of the thin copper is also decreased still further under such treatment. If glass-to-copper tube seals are subjected to thermal cycles (heating and cooling) the thin copper may fail because it is being continually work-hardened. Copper seals cannot be used with mercury because the latter will amalgamate with copper. However, copper can be electroplated with a suitable metal after the seal is completed. The tube in Fig. 82E was nickel-plated after the seal was made.

Machining a copper tube end to a thin edge is sometimes quite difficult unless a metal backing is used to reinforce the tube. A tight-fitting plug can be made which fits into the tube. An alloy, Cerrobend,[10] is also useful for reinforcing a copper tube. This eutectic alloy has a melting point of

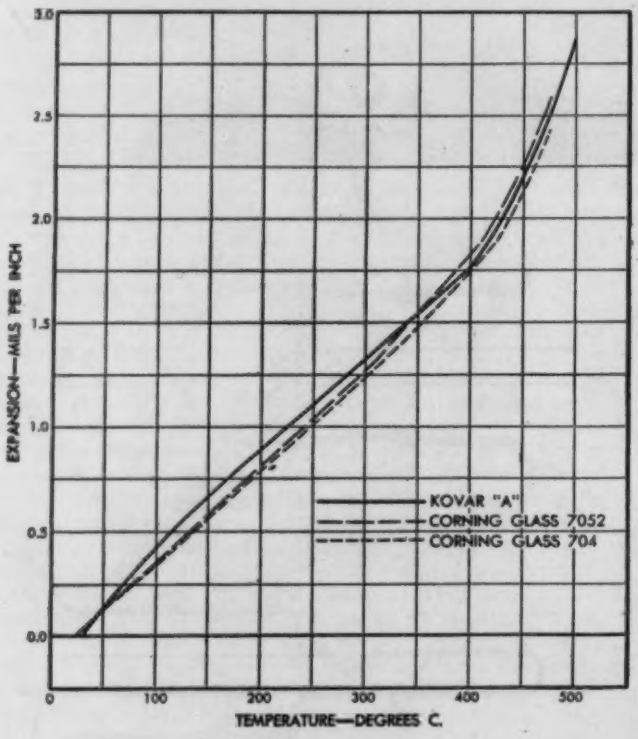


Fig. 87

160°F. and does not adhere to the copper. It is melted and poured into the tube which is machined after the alloy has hardened. After the machining is complete, the alloy is removed by melting.

Dumet

Dumet as described by B. E. Eldred[2] is made by coating a billet of nickel steel with copper and drawing the coated billet to a wire. The nickel-steel core of the finished wire contains 38% nickel and about 20% to 25% by weight of copper. This wire is still used extensively in lamps and vacuum tubes.

The temperature coefficients of expansion of Dumet are approximately as follows:

Radial, 80-100 × 10^{-7} per °C.
Axial, 61-65 × 10^{-7} per °C.

From these coefficients of expansion it can be seen from Table 11 that the seal will be badly strained when G-5 glass is used. Seals with this glass have been successful because the low yield point of copper sets a limit to the stress exerted. The wire, 1 mm. or less in diameter, is satisfactory for glass-to-Dumet seals. Lead glass, G-5, can be used for beading this wire. It is beaded by the same procedure outlined for making glass-to-metal seals with platinum. Since Dumet is comparatively expensive, it is only used in lengths necessary for the glass-to-Dumet seal. Lead wires of nickel and copper are butt welded to the two ends of the Dumet wire for the press welds.

Kovar

Kovar, a nickel-cobalt-iron alloy, was developed and perfected by the Westinghouse Electric Corporation. It, and the alloy Fernico which is used by the General Electric Company, have a specific temperature coefficient of expansion which is nearly the same as some of the standard glasses. A comparison of the thermal expansion of Kovar with Corning glasses 7052 and 704 is shown in Fig. 87. The specific properties of Kovar are given in Table 14.

TABLE 14. SPECIFIC PROPERTIES OF KOVAR

Composition	29% nickel, 17% cobalt, 0.3% manganese, 52% iron
Melting Point	Approximately 1450°C.
Density	0.302 lbs. per cubic inch
Hardness, Annealed	760°C. 140 to 160 B.H.N.
Hardness, Unannealed	200-250 B.H.N., depending on degree of cold work.
Electrical Resistivity	49 Microhms $(cm.^2)/(cm.)$
Thermal Conductivity	0.046 calories/(cm.)(sec.)(°C.)

Since Kovar has thermal expansion properties which are very close to those of several standard glasses, the alloy need not be machined to feather edges as previously described for copper. This alloy can readily be machined for glass-to-Kovar seals. The sealing surfaces should be free from marks or scratches which extend across the sealing surface. (Other marks are not objectionable.) Glass should not be sealed to surfaces of Kovar parts which have sharp corners; the edges should be rounded with forming tools.

Kovar sealing surfaces must be thoroughly clean and free from gas or gas-forming components. If the surface is not degassed before sealing to glass, gas bubbles will form at the glass-metal interface as the seal is made. These bubbles will impair the mechanical strength of the seal. Kovar is degassed by heating it in a furnace to a temperature of 1050°C. for a period of 20 minutes. Hydrogen which is bubbled through a water trap is fed into the furnace to maintain a hydrogen atmosphere. The metal is moved to a cooling section of the furnace and cooled to 300°C. before it is removed from the furnace. Degassed Kovar should not be touched with the hands—especially the surfaces which are to be used for the glass seal. Glass-to-Kovar seals should preferably be made within three hours after the alloy is degassed.

Kovar must be oxidized before glass can be sealed to it. This alloy may be oxidized during the sealing operation by heating it to about 650°C. in the oxidizing portion of the burner flame, or, it may be pre-oxidized in a furnace. The degree of oxidation for good seals is difficult to determine and a procedure of obtaining a suitable state of oxidation is best gained by experience. Heavily oxidized Kovar yields mechanically strong seals, but these seals are not vacuum-tight. Under-oxidized Kovar yields hermetic seals which are mechanically weak.

If the Kovar is oxidized in the burner flame, 7052 glass is sealed to the alloy while the temperature of the alloy is still between 650 and 800°C. The glass is fused and attached to the metal. If the seal is small, the glass and Kovar, which is suitably mounted, can be worked by hand. Larger seals are best made by using a glass blower's lathe. A new procedure of applying glass to Kovar has been developed by engineers of the Westinghouse Lamp Division.[12] The oxidized Kovar surface which is to serve as glass-to-Kovar seal is covered with powdered glass by suspending the latter in a suitable solvent and spraying the mixture on the Kovar. The metal and glass are then placed in a furnace and heated until the powdered glass is fused to smooth film on the Kovar. Glass can then be sealed to the glass on the Kovar by the simple procedure of fusing glass-to-glass. The glass-to-Kovar seal is not affected by the second sealing operation.

Annealing Glass-To-Kovar Seals

When glasses 704 or 7052 are used with Kovar, seals can be obtained which are nearly stress-free by the annealing technique previously described for annealing glass-to-glass seals. The seal is heated to dull red heat in the annealing burner and covered with a deposit of carbon by turning down the air supply to the air-gas annealing burner.

Furnace annealing is accomplished by heating the seal to 484°C. and maintaining this temperature for twenty minutes. The temperature is then lowered 1°C. per minute to 450°C.; and then about seven to ten degrees per minute to room temperature.*

The oxide on Kovar surface must be removed after the glass-to-Kovar seal is made if the alloy is to be soldered, welded or brazed. A solution of 10% HCl and 10% HNO_3 in water, heated to 71°C. (or 160°F.) can be used for cleaning the oxidized surface. The Kovar is immersed in this solution for five minutes, washed thoroughly with water and dried.

Kovar can be welded with an electric arc. The electrodes should be of the fluxed cooled type and of "18-8" stainless steel (with 18% chromium and 8% nickel). When welds are made on Kovar which has glass seals, one should remember that the metal will conduct heat more rapidly than the glass. The alloy, between the glass seal and the position which is to be welded, must be cooled to prevent heat from flowing too rapidly to the glass seal. The glass and Kovar can also be heated to prevent uneven heating during the welding operation.

Kovar is copper-brazed by using pure copper on the clean alloy surface. A small piece of copper is placed on the alloy surface and the two are placed into a hydrogen-atmosphere furnace. The Kovar is heated from room temperature to 1100°C. in one hour* and this temperature is maintained for 15 minutes. The hydrogen performs as a flux.

Kovar can be obtained in rods, wire, tubing, sheet or special forms, such as cups, flanged cups and flanged eyelets.

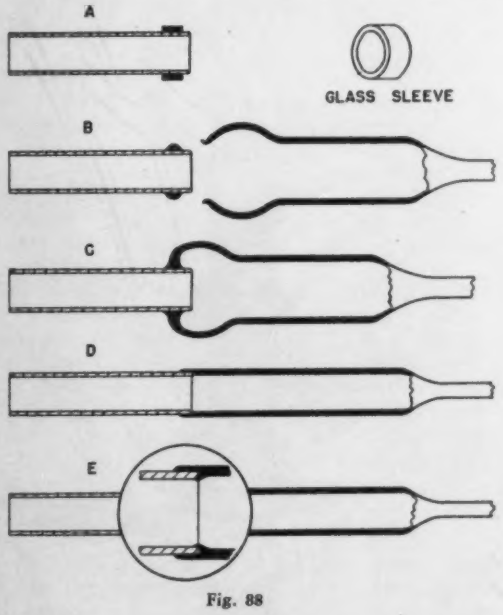


Fig. 88

Stupakoff Ceramic & Mfg. Co., Latrobe, Pennsylvania, is the distributor of this alloy.

Procedure for Making Glass-to-Kovar Seals

As an example of making a glass-to-Kovar seal, a description of the procedure for sealing glass to a Kovar tube will be described.

1. A band of Corning glass 7052, 6 mm. in length, is cut from the glass tube which has a diameter just large enough so that the small section can be slipped over the Kovar tube, Fig. 88A.

2. A point is drawn on a tube of Corning glass 7052. The tube should have the same diameter as that of the glass band, or it can be drawn down from a larger tube and cut open in the burner flame. The end must also be expanded to a bulb and opened if a small tube is used.

3. A short section of Kovar tubing, which has been degassed under conditions previously described, is mounted on a glass holder with asbestos tape. The sealing surface

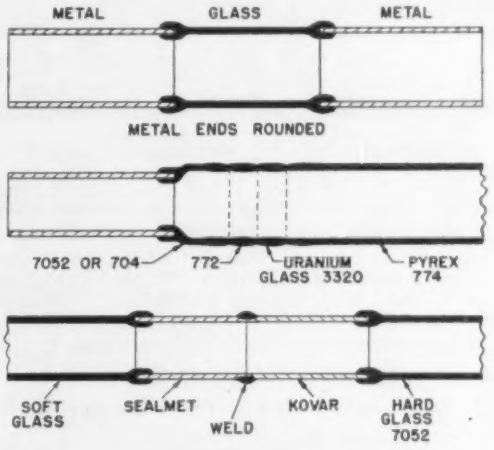


Fig. 89

should be clean and the tube should not be handled at the sealing surface.

4. The Kovar is then oxidized by heating it to a dull red heat. It is removed from the flame and allowed to cool slightly.

5. The short section (6 mm.) of 7052 glass tubing is slipped over the oxidized Kovar tube and a small spot of the glass is fused to the alloy tube to prevent it from slipping, Fig. 88A. The tube is then rotated until the glass is fused sufficiently so that it can be tooled against the Kovar. One must be careful not to occlude any air between the glass and metal interface as the seal is made. To avoid this, it is best to start to tool the glass at one end and gradually work the glass against the metal until the other end is reached. In Fig. 88B the seal is shown well back from the edge of the tube.

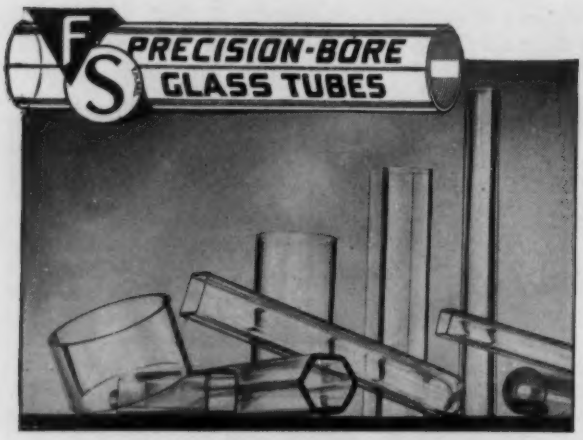
6. The glass tubing is then sealed to the bead glass which is sealed to Kovar by the technique of making a glass-to-glass seal, Fig. 88C. The seals are then annealed by heating in the annealing burner flame, or in an annealing furnace, according to the procedure previously outlined.

Two other seals are shown in Fig. 88D and 88E. The seal glass in Fig. 88D extends to the end of the Kovar tube, while in Fig. 88E the glass extends over the end of the rounded edges of the tube.

The seal illustrated in Fig. 89A is a combination of an internal and external seal. The seal glass is worked over the edge of the Kovar much in the same manner as was described in sealing glass to a copper tube.

If the glass-to-Kovar seal is attached to Pyrex, a graded seal must be made between the 7052 glass and Pyrex. This graded seal is made by starting with a Pyrex tube. This tube is drawn to a point and allowed to cool. The Pyrex tube is then opened at the opposite end with the flame. A tube of uranium glass 3320 is butt-sealed to the Pyrex tube with a minimum of working the two glasses. The seal should be thin. The uranium glass is then cut 4 mm. from the seal. A tube of 772 glass is sealed to the uranium glass and the tube of 772 is cut with the flame 4 mm. from the second seal. The graded glass seal is then sealed to the 7052 glass tube, Fig. 89B. A glass-to-Kovar seal with a graded seal is shown in Fig. 84A and Fig. 82B. The same glass-to-Kovar seal is shown in Fig. 84B. In this example, how-

*Editor's Note.—Only in factory production, with high-precision automatic temperature-time control systems, can these recommendations be met *exactly;* most readers would have to rely on all-purpose laboratory furnaces. However, two or three degrees more or less at the holding temperature, and a few minutes longer or shorter in the controlled rate-of-change periods, will not matter.—M. F. Behar.



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ever, the glass-to-Kovar seal was made so that the Kovar tube extends beyond the glass-to-Kovar seal. The glass tube has a small bulb beyond the 7052 glass seal. The seals illustrated in Figs. 84D and 84E are made of glass 7052 and Kovar.

A method of connecting soft glass to Pyrex is illustrated in Fig. 89C. A tube section of Sealmet is welded to Kovar. Soft glass is sealed to the Sealmet and 7052 glass is sealed to the Kovar by procedures outlined above.

Another example of glass-to-Kovar seals is illustrated in Fig. 90. Here two seals of 7052 glass-to-Kovar are used to seal the top and extension tube of a trap to the body of the latter which is 7052 glass. The two graded seals of 772, uranium glass and Pyrex, are noticeable on both the inlet and outlet tubes.

A Kovar-to-glass, 7052-to-Kovar, is illustrated in Fig. 82B. An example of a method of connecting a small steel boiler to a Pyrex system is shown in Fig. 82C. The order of the various glasses and metal, top to bottom is as follows: Pyrex, uranium glass, 772 glass, 7052 glass, Kovar, and steel. The steel boiler is fitted with a circular electrical heater which is bolted to the flat bottom.

Kovar rods are frequently used as conductors through glass. An example of four large Kovar conductors through a glass cap is illustrated in Fig. 91. The Kovar rods are fitted with special caps for the glass-to-Kovar seals. The tubulation in the center is used for evacuating the finished tube which will contain the four sealed conductors. The tubulation has heavy walls so that it can be tipped-off by fusing the glass.

Glass-to-Kovar seals have been made by using induction heating instead of a gas-oxygen flame. The high-frequency (40-60-kc.) current is supplied by spark or vacuum-tube

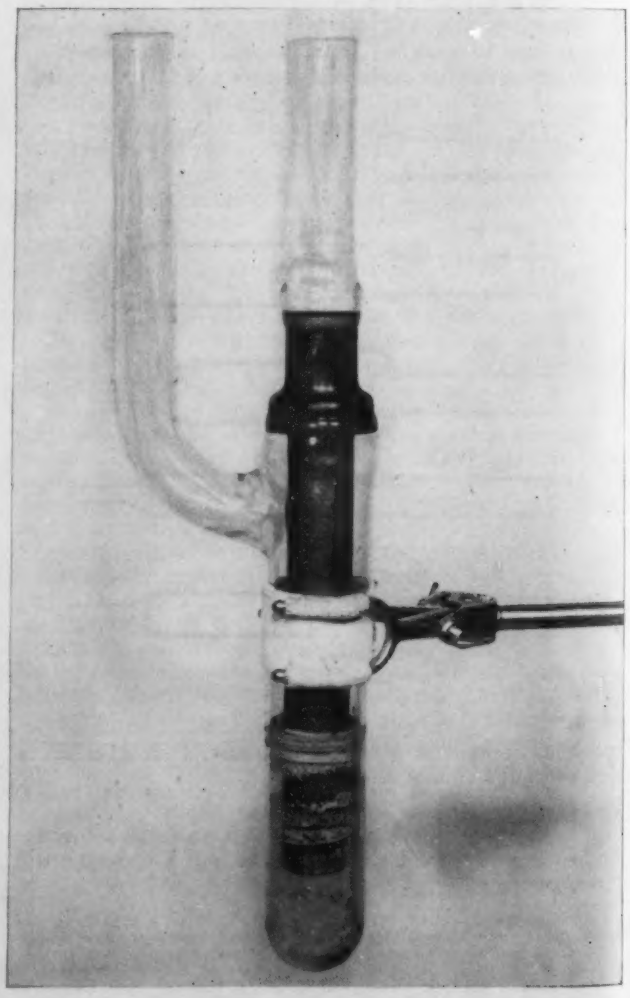

Fig. 90

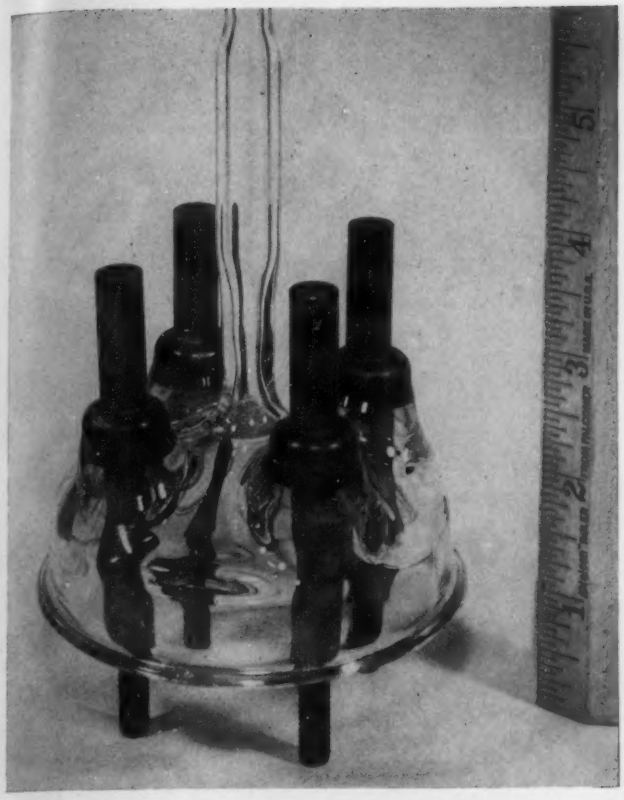

Fig. 91

generators. It is important that the glass and metal parts be in intimate contact because it is the Kovar which is heated by induction, and the adjacent glass is fused by the conduction of heat from the Kovar. This method is useful when it is desirable to make glass-to-Kovar seals on small Kovar parts. The fusion of glass is rapid and the control is quite easy.

Small glass-to-metal seals can be made by hand, but when large seals are required the glass blower must use a lathe. There are two distinct advantages in using a lathe for making large seals:

1. Large and cumbersome sections of glass and metal can be handled by the lathe and the glass blower can use both hands for tooling the glass and directing the flame over various sections of it.

2. The glass and metal are truly centered in a lathe to produce precision seals.

The popular Litton lathe, Model EE[13] is shown in Fig. 92. The head stock at the left is synchronized with the tail stock at the right. The Litton cross-fire which is being used is adjusted in the form of an arc which covers nearly one-half of the circumference of the glass. This burner can be moved, either to the left or right, by the hand wheel behind the burner. The operator is tooling glass against a Kovar surface.

Sealmet

An alloy which contains 51.55% by weight iron, 42% nickel, 6% chromium, 0.12% silicon, 0.29% manganese and 0.04% carbon was developed by the Higrade Sylvania Corporation.[14] This metal has a thermal coefficient curve very close to that of Corning glass number 001. This glass is used in making glass-to-Sealmet seals and the glass is then sealed to the envelope of Corning glass 008. The procedure for making glass-to-Sealmet seals involves techniques very similar to those described for Kovar. Technical data concerning Sealmet can be obtained from the Allegheny Ludlum Steel Corporation, Pittsburgh, Pennsylvania.

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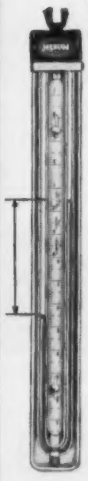

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Fig. 92

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for commercial use. Experimental lamps or bulbs, however, are sometimes required in the laboratory. Since it is not economical to invest in production machines for laboratory work, the procedure for making lamps and tubes by hand will be described.

Two methods can be used for sealing electrodes into tubes. The electrodes are either bead-sealed into the lamp or tube-flare or press-sealed into the glass of the flare. The number of electrodes which can be sealed into a flare will depend on its size.

Single-wire electrodes are made as follows:

1. The flare is made by pulling a point on a tube with the required diameter. The flare is formed on the opposite end by the procedure outlined in Chapter II and illustrated in Fig. 39.

2. This flare is mounted on the glass tube with asbestos tape; the opposite end is shaped for the seal. If the bead seal

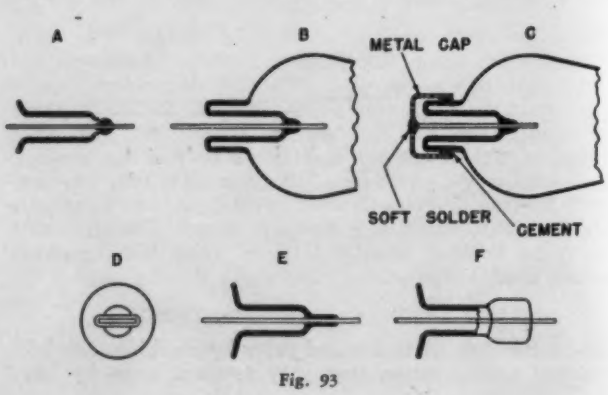

Fig. 93

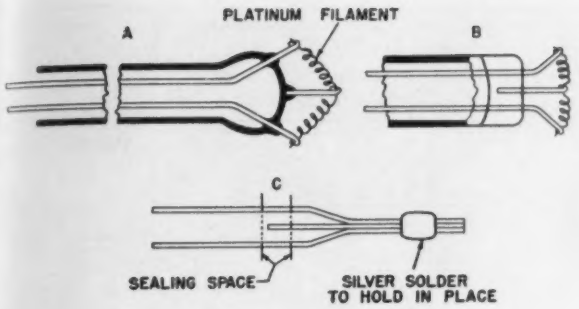

Fig. 94

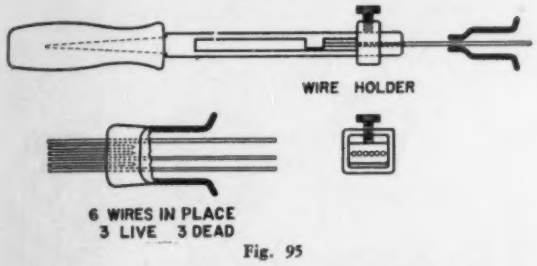

Fig. 95

is used, the opening is made by pulling the tube to a cone and opening this cone. The flare is illustrated in Fig. 93A. The wire is then beaded by the procedure recommended for the type of wire used and the glass bead is sealed to the flare. The assembly is carefully annealed and then sealed into the bulb or tube, Fig. 93B. The electrode is soft-soldered to a cap after it is cemented to the tube, Fig. 93C.

The press seal is used almost exclusively in commercial

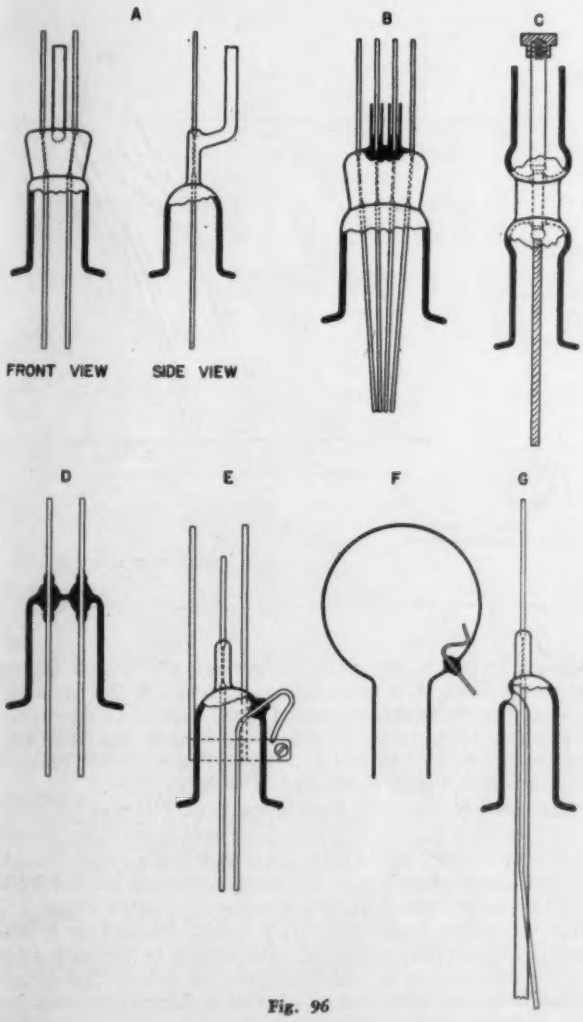

Fig. 96

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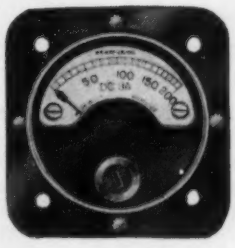

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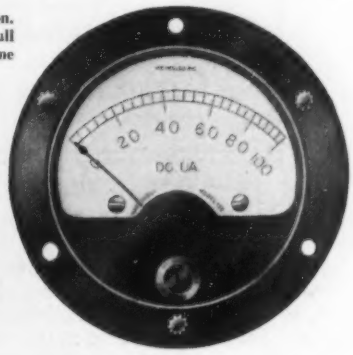

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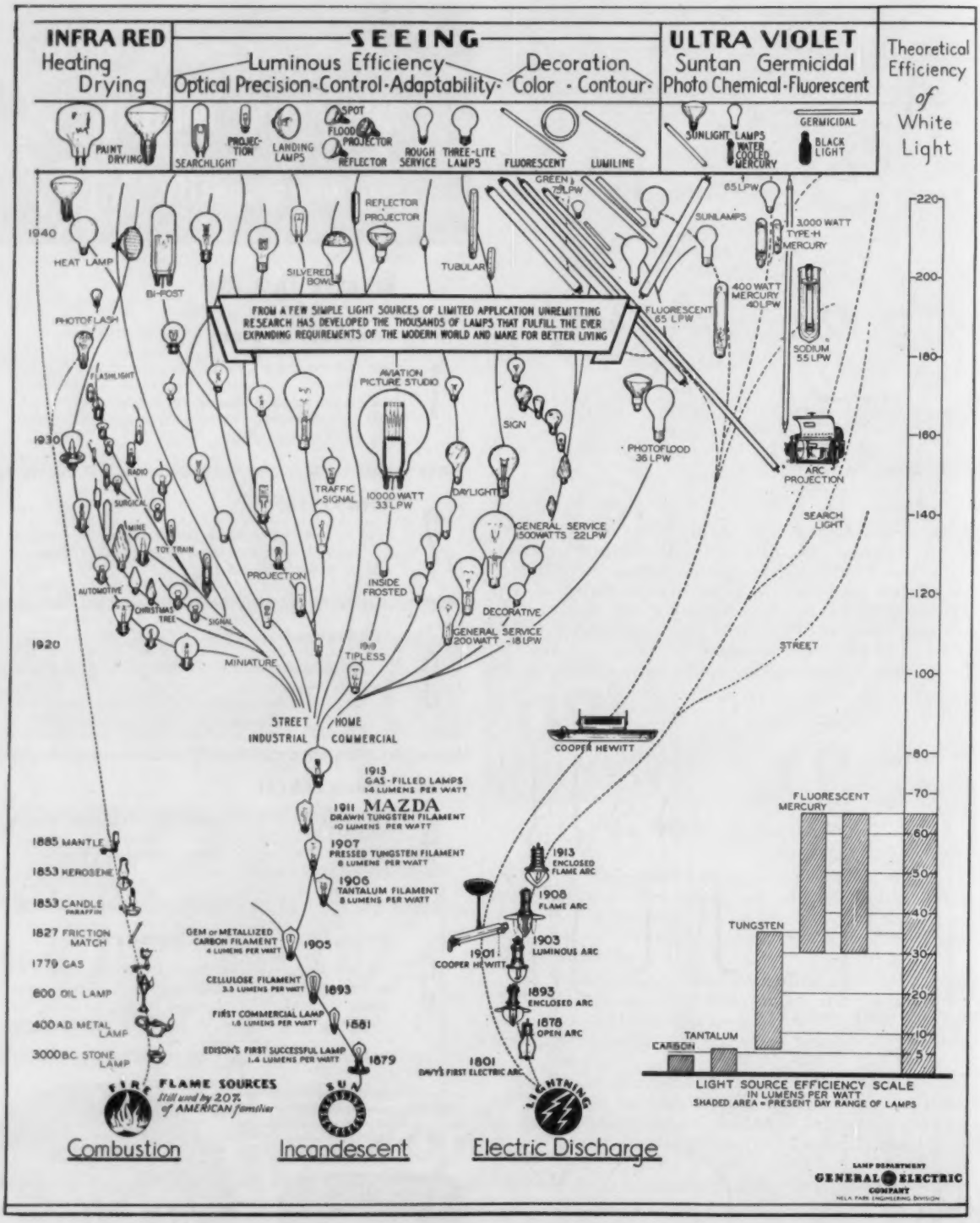

production because it is more easily made in machine production.

1. The flare is made with a triangular tool as described above. This flare is then mounted on a glass tube and the end of the flare-tube is fused and pressed until the end has a form shown in Fig. 93D.

2. The wire is then placed into the glass end and the glass is fused and pressed against the wire. The press seal when correctly made will appear as shown in Fig. 93E and F. The seal is carefully annealed.

3. The flare is then sealed into the tube by a procedure of sealing a flare to a tube. The electrode is then soft-soldered to a cap which is cemented to the tube.

Multiple electrode seals are used more extensively for laboratory installations. Beaded wire electrodes are more difficult to make, especially if several are sealed through the same flare. It is more convenient to use the press seal because the wires can be spaced more easily. As an example of the two types of seals, the production of the flare for a combustion pipette will be described. The electrode assembly consists of two lead wires and a wire support.

The beaded electrode flare is made as follows:

1. The tube for the beaded electrodes is made by blowing a bulb on the end of the tube. This bulb will allow more space for the glass-beaded wire. Two electrodes are beaded by the procedures described in this chapter. Tungsten press welds may be used. These prepared beads consist of a small length of tungsten which is butt-welded to braided copper on one end and to a nickel rod on the other. The beading procedure has been described for making tungsten bead

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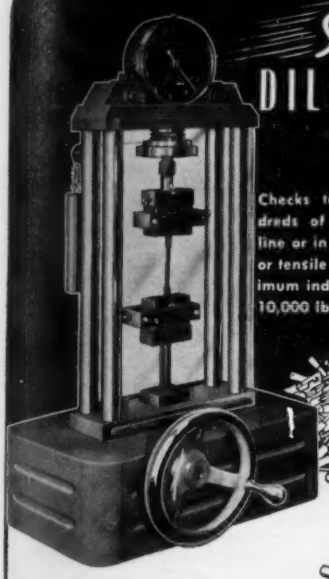

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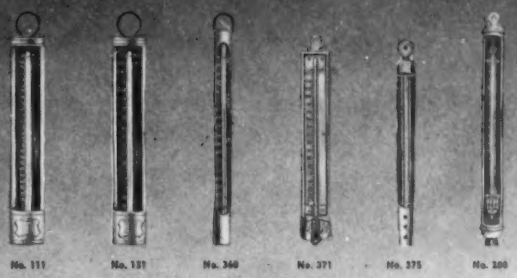

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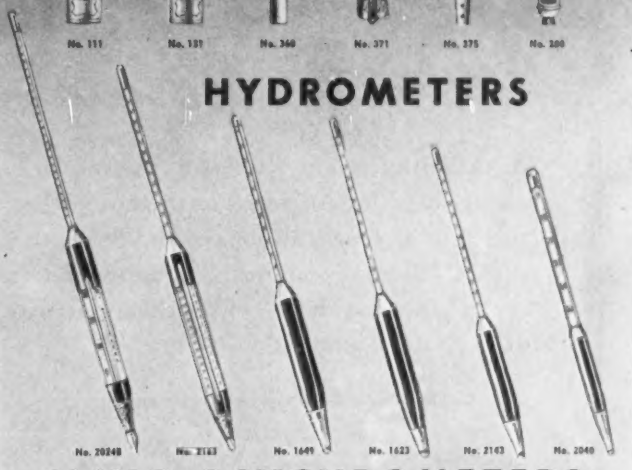

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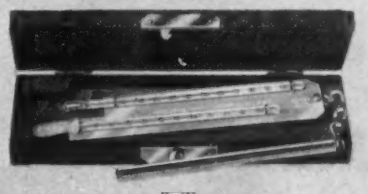

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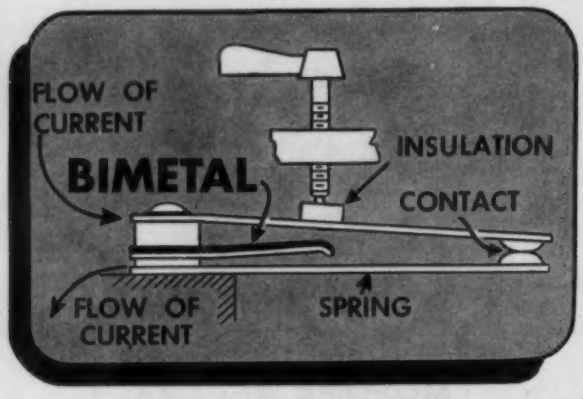

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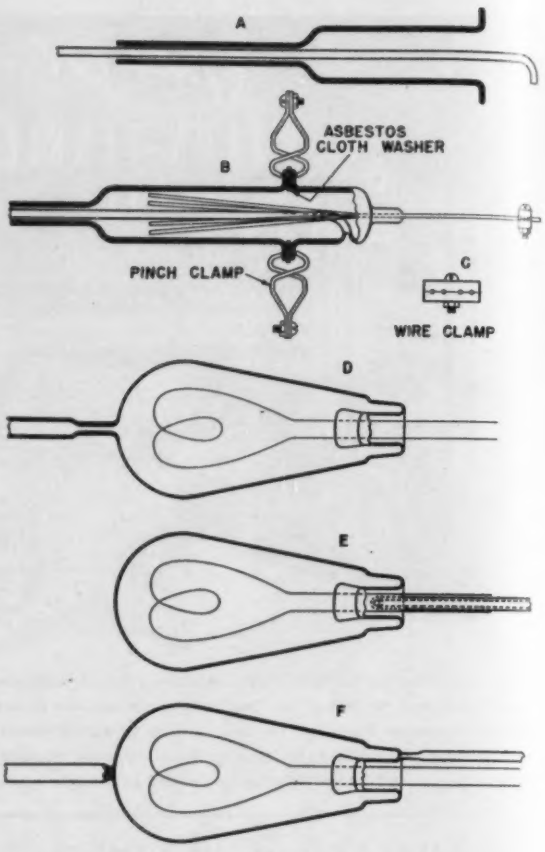


Fig. 97

seals. The filament support has the glass beaded over one end. The three are then sealed into the glass and the filament is spot-welded to the leads (Fig. 94A) after the seals are annealed.

The press seal can be made in about one-third the time required for the beaded electrode seal. The press is made by fusing the end of a tube and pressing it together so that there is just room enough to insert the electrodes. The electrodes and support are silver-soldered together so that each will be held in place by one common holder, Fig. 94C. The electrodes are then put into the press so that the filament support extends to about the middle of the press. The glass is fused and pressed against the electrodes. The assembly is then annealed. The silver solder is removed and the electrodes are bent to the desired angles. In bending electrodes, one should always hold the electrode near the seal with pointed pliers to avoid cracking the seal. The platinum filament is then spot-welded to the electrodes, Fig. 94B.

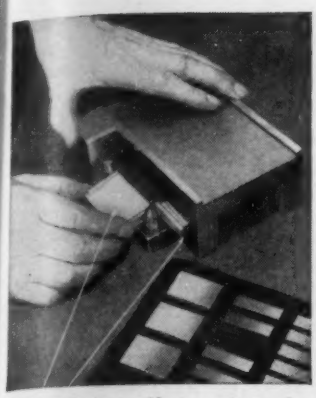
When a larger number of electrodes are to be press sealed into glass, it is convenient to use the simple wire holder shown in Fig. 95.

Various types of vacuum-tube stem mounts are shown in Fig. 96. The construction of these mounts consists both of the bead and press seals; and numerous modifications can be incorporated into specific assemblies by using construction details from several of the electrode arrangements. These mounts may be used with any of the standard glasses if the correct metal and sealing procedure is used.

Glass rod supports are sometimes convenient and may be sealed to press seals as shown in Fig. 96A. The side view shows the shape of the glass rod. It is best to seal the rod to the press after the wires are sealed in. The rod is straightened after the press seal is completed.

When two electrodes carry sufficient current to cause a short circuit by arcing, it is advisable to seal lengths of 3 mm. O.D. tubing above the seal. The press seal with insulating tubes is shown in Fig. 96B.

The seal illustrated in Fig. 96C is made by using a press weld sealing wire. The lower section is braided copper welded to a metal which can be sealed to glass. The upper



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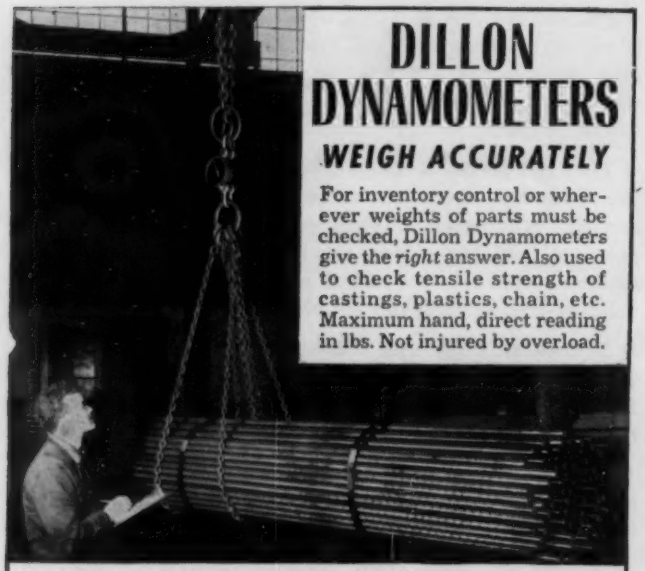

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section, containing the metal plate, is also made of a different metal which is press-welded to the short glass-sealing metal.

A simple two-electrode bead seal is illustrated in Fig. 96D. The seal glass which is beaded to the metal extends beyond both sides of the bead seal.

A convenient method of mounting a plate is illustrated in Fig. 96E. The clamp which supports the plate is fastened and held in position on the flare while the other electrodes are press-sealed through the end of the flare tube.

A lead which contacts the inner surface of a bulb is used in special photoelectric tubes. This electrode seal is illustrated in Fig. 96F. The electrode contacts the inside wall of a tube or bulb which is covered with a metal coating.

A hand-made "tipless press" is illustrated in Fig. 96G. A small thin tube is sealed into the flare. This tube is then used to evacuate the bulb after it is made. The procedure for making this assembly is as follows:

1. A special holder must be made as shown in Fig. 97A. The tube, which has a diameter equal to that of the proposed flare, is sealed to a smaller tube which has an inside diameter of about 5 mm. The large tube section is then flared by the same procedure used in making the tube flare. The tip-off tube can then be held in place as illustrated.

2. The electrodes are press-sealed into the tube flare by using a spacer clamp or a wire holder. The tube-flare is then mounted on the tip-off tube holder as illustrated in Fig. 97B. The tip-off tube is then sealed to the inner wall of the flare. The glass over this small tube is blown out to a small bulb and collapsed several times to insure a good seal. The glass is then blown out to a thin bulb and the opening is fire-polished. When the flare is sealed to the bulb, the small tube is protected from the heat by slipping a quartz tube over the small tube.

Three types of tip-off tubes or tubulations are illustrated in Fig. 97D, E and F.

1. The tubulation at the tip of the bulb is given in Fig. 97D. The bulb is evacuated through this tube and it is then sealed by fusing and drawing the tube from the bulb. Although this type is quite convenient because the tubulation serves as a handle, it is not used in commercial practice at the present time.

2. The type shown in Fig. 97E has been discussed above.

3. The type shown in Fig. 97F is made by using a temporary blowing tube on the bulb and sealing a tube to the edge of the flare. The temporary tube is then removed and the bulb is worked to a smooth surface at this point. The bulb can then be evacuated through the tubulation and sealed by closing and drawing away the small tubulation at the edge of the flare. *To be continued*

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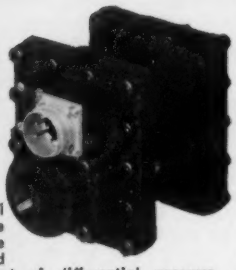
STATHAM PRESSURE TRANSMITTER

Model P7



Statham Model P7 Pressure Transmitters are recommended for measurement of differential pressure in systems containing fluids which cannot be permitted to come into direct contact with the Statham Gage filaments.

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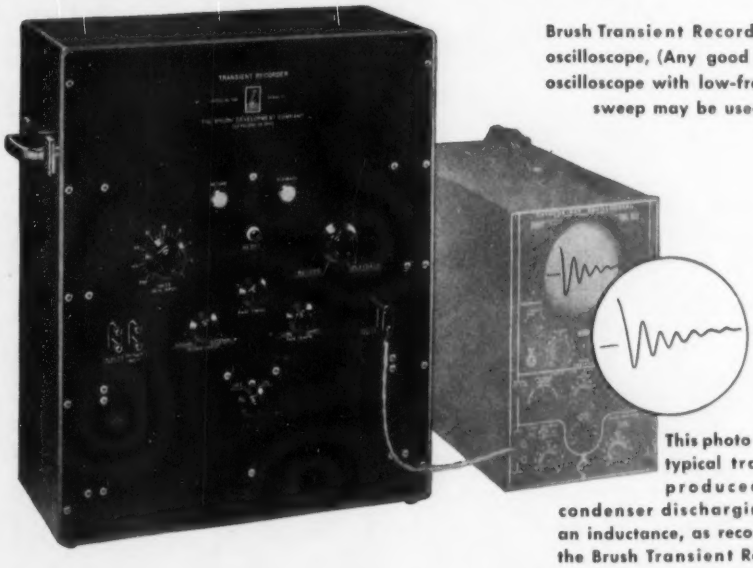

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The Month's NEW INSTRUMENTS

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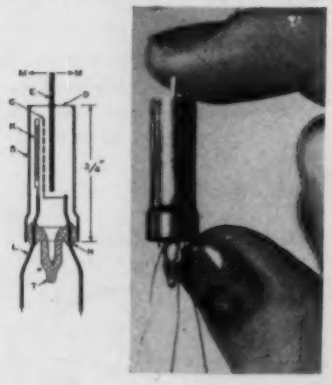
Mechanical-displacement-input Electron Tube

New "Vibrotron" is an inexpensive, practical embodiment, suitable for mass production, of method formerly used only by



experimenters in various laboratories, and reported only in scientific journals, whereby motion imparted to an externally-protruding element alters the electron flow in a vacuum tube. Its first large-scale application will be in phonograph pick-ups, but announcement states that other fields of application are in industrial measurement and automatic control equipment. Announcement mentions that although "Vibrotron" is not yet in production, a limited number would be made available to manufacturers of electronic equipment who are interested in experimenting with it for use in their future products. New tube weighs approx. 0.2 oz., is about 1" long by ¼" diam. Our illustrations show it in actual size. Motion of movable electrode E is transferred through thin metal diaphragm D. Triode consists of cathode K, grid G, and movable anode E. Motion of movable anode in direction MM produces a proportionate change in electron flow. Triode is contained within metal envelope S and has its leads L brought out through vacuum-tight glass header H with exhaust tip T. Development has covered a period of several years and it is said that life tests have shown tube to be "especially stable under temperature and humidity changes," as well as able to "withstand severe treatment over long periods of time."—*RCA Victor Division, Radio Corp. of America, Camden, N. J.*

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Continuously-indicating Vacuum Gage

New ion gage, able to measure or monitor continuously the highest vacuums ordinarily encountered in factory or laboratory processes, consists essentially of a control unit and an ion gage tube, measures pressures as low as 10^{-7} mm. of mercury. Its continuous pressure indication permits detection of small pressure changes and measurement of slow pressure drifts without the inconvenience of continual adjustments. A protective circuit is provided in control unit to turn off gage filament automatically at pressures above 10^{-4} mm. Control regulates filament emission against line voltage and pressure changes, assuring

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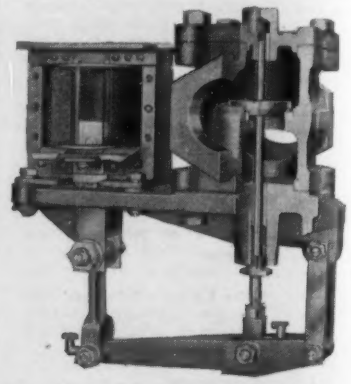
stable operation. Ion gage control unit includes emission regulator circuit, a stabilized voltage supply, an electronic microammeter with indicating instrument, and filament protective relay. Front panel contains all controls necessary for operation of ion gage. Gage tube is a special glass triode with a tubulation for connecting to the vacuum system. In operation, gage tube is sealed to high-vacuum system and tube is connected electrically to control unit. Once preliminary adjustments have been made by use of the panel-mounted switches and controls, only infrequent adjustments are required over periods of several hours. —*General Electric Co., Schenectady, N. Y.*

Please mention number 702 when filling out card

Direct-acting Solenoid Valve for High Differential Pressures

New direct-acting solenoid valve is said to make advantages of an automatic electric valve available for a wide range of applications. It combines immediate full flow with ability to operate under differential pressures as high as 150 lbs./in.². It can be used for all systems of liquid level control, with hot and cold water, steam, oil and other processing liquids. Solenoid is conservatively rated and lever arrangement provides ample power to insure positive opening of valve. Single-seat construction, manufacturer points out, eliminates trouble sometimes encountered with pilot-operated valves when silt or other foreign matter freezes piston. It also increases temperature range to 365° F. In normal position, valve is closed; when solenoid is energized, valve opens instantly to full capacity. Valve is



designated as a globe screwed type, and is designed and built for heavy-duty service. Body is of cast iron or bronze, tested for 150-lb. pressure, with top cap and bottom section bolted to body. Seat and valve stem are all of stainless steel. Available in two series: "Type HH," sizes from ⅛" to 1½" suitable for differential pressures ranging from 125 to 150 lbs./in.²; "Type HL," sizes 1" to 3" for medium and low differential pressures. Standard models operate on 110-, 220-, or 440-volt 60-cycle supply.—*Johnson Corp., Three Rivers, Michigan.*

Please mention number 703 when filling out card

Paper Tubular Capacitors

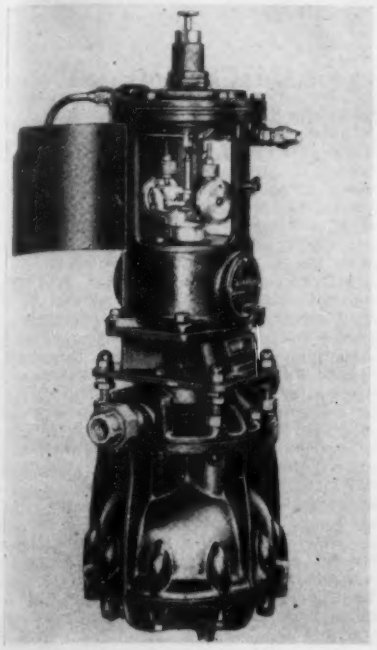
New paper tubular capacitors for by-pass and special-circuit applications, have capacitance ratings ranging from 0.001 to 1.0 microfarads at voltage ratings of 200, 400, 600, and 1000 volts d.c. Manufacturer also announces expansion of facilities for large-scale production of special design "midget" capacitors, which were formerly used in the "Proximity Fuze."—*J. P. O'Donnell and Sons, 316 Stuart St., Boston 16, Mass.*

Please mention number 704 when filling out card

Viscous-fluid Flow-rate Meter with Positive Primary Element

New "Transometer" now makes possible control, integrating, remote indicating and recording, of heavy fuel oil. It is a combination of a piston-type positive-displacement meter and a pneumatic signal transmitter; and is said to be equally valuable with other liquids—particularly viscous fluids—because its accuracy is unaffected by viscosity changes. Having ample power, even at lowest flows, it is said to be ideal for applications where wide flow variations are encountered. *Operating principle:* "Transometer" is, in principle, a fly-ball governor, the centrifugal force of which is balanced by a diaphragm under air pressure. Shaft is driven by extended shaft of positive-displacement meter. As speed of meter changes, fly-ball governor exerts a vertical force according to speed of meter and, since centrifugal force changes with

square of speed, force of governor will vary as square of rate of flow through meter. Vertical force of governor is transmitted to an Askania jet pipe, into which air under pressure is introduced. Air leaving jet pipe



enters a receiving nozzle which communicates with a diaphragm at the top, setting up a counter-force on jet pipe. Position of the pipe will always be such that air pressure on diaphragm balances centrifugal force of governor. As a result, air pressure signal will be in direct proportion to speed of governor and therefore a square function of oil flow through displacement meter. Pressure changes of entering air do not affect accuracy of "Transometer" since jet pipe always finds a position in which air pressure on diaphragm balances opposite force of governor. Positive-displacement meter used in conjunction with "Transometer" can be furnished with a counter giving direct readings of total fuel consumption. Recording or indicating instruments with evenly-divided or square-root scales, can also be furnished. —*Askania Regulator Co., 1603 S. Michigan Avenue, Chicago, Illinois.*

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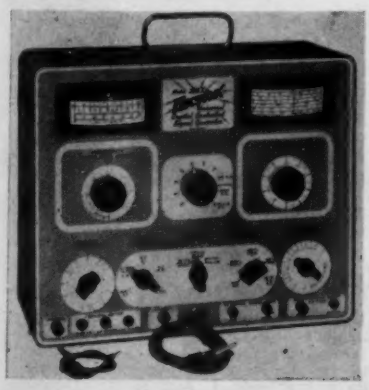
Crystal-controlled Signal Generator

New signal generator has a wide range in radio- and audio-frequencies, power consumption 20 watts at 115 volts. Among its features are: Complete AM coverage from 100 kc. to 110 Mc. Complete FM coverage 100 kc. to 160 Mc. with three variable



bandwidths of sweep: 0-30, 0-150, 0-450 kc. FM. at two self-contained modulating frequencies: 60 and 400 cycles. Provisions for external AM & FM to 15,000 cycles. Self-contained AM at 400 cycles, 0.01% accurate crystal-controlled outputs, both amplitude modulated at 400 cycles and unmodulated. Continuously variable a-f. from 0-15,000 cycles. A-f and r-f. outputs continuously variable from zero to maximum. 60-cycle synchronized sweep voltage available for use with an oscillograph. Self-contained decibel meter with 42" cable. Dimensions: 14" × 16½" × 8". Weight: 28 lbs. Scale: Over 100".—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

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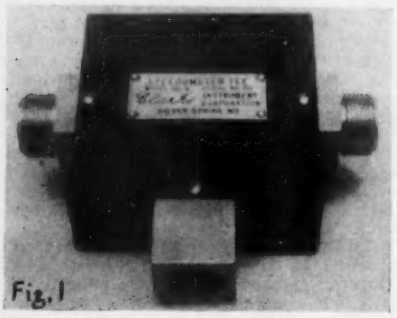
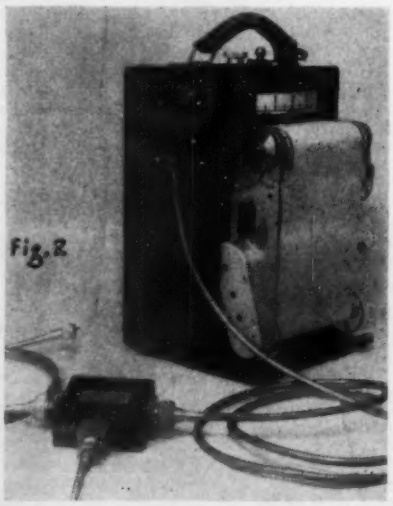
Equipment for Mobile Recording of Field Intensity

New complete equipment for adapting standard Esterline-Angus recorders for mobile recording of field intensity as required by the F.C.C. in proof of performance of FM and television stations includes "Type 101" Speedometer Tee, and "Type



102" Recorder Drive Mechanism, Fig. 2, together with all necessary interconnecting cables. Tee is permanently mounted on the dash or bulkhead of the car and provision is made for normal operation of the speedometer. Recorder drive can be attached to or detached from recorder in five seconds without aid of tools and does not interfere



with normal operation of recorder for any other applications. Chart speeds of 1", 2", 4", 8", or 16" of chart per mile traveled can be selected at will. A control is provided for instantly engaging or disengaging the drive when it is desired to omit recording in areas of no interest to the survey—*Clarke Instrument Corporation, 910 Jackson St., Silver Spring, Md.*

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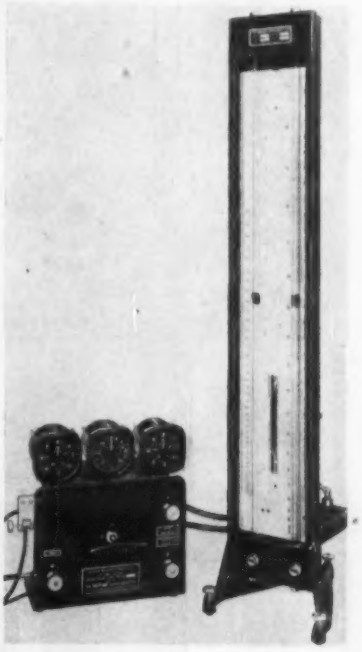
Airspeed Indicator Test Unit

New "Model A-921 Airspeed Indicator Test Unit," for calibrating airspeed indicators, consists of a pressure generator unit



and a two-tube manometer with scales graduated directly in air speed. Manometer, being a primary standard of measurement, is universally used as the reference standard in checking and calibrating airspeed indicators.—*The Meriam Instrument Co., 10958 Madison Ave., Cleveland 2, Ohio.*

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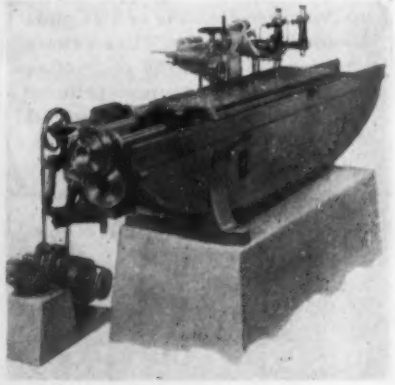
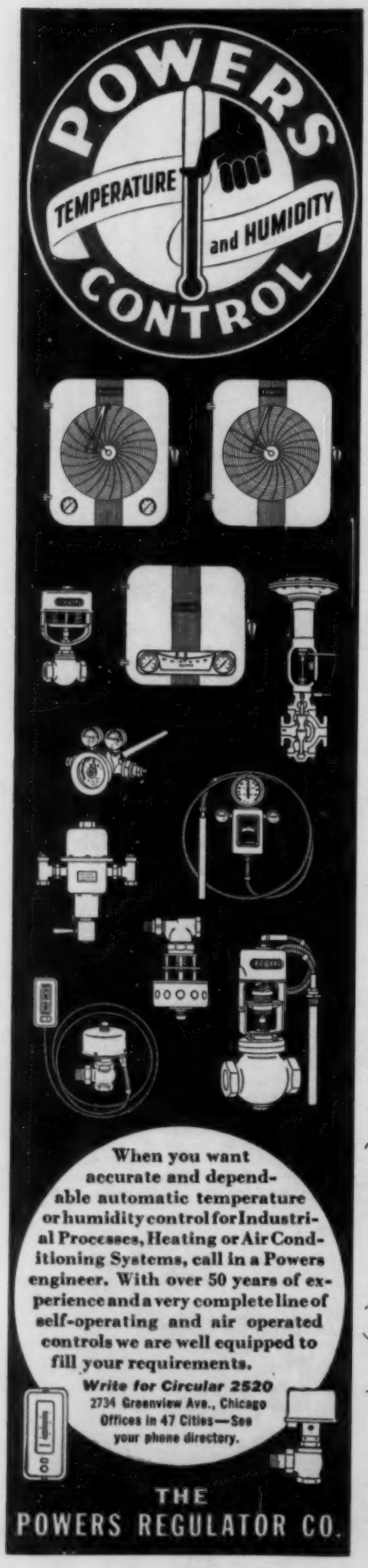
Fully-automatic Linear Dividing Machines

Several new models are added to maker's line of automatic linear dividing machines. These machines automatically rule highly accurate linear scales of practically any pattern or spacing having industrial or scientific application. They retain precision at rapid production speeds. Largest model will rule a continuous scale up to 40" long at a rate of 60 or more lines per minute with a rated accuracy of ±0.0001". Models of lower precision and models of smaller capacity are also offered. Each machine is capable of ruling any one of a large variety of line patterns with up to four different line lengths in a given pattern. Also, each machine will rule scales in either the inch or the metric system as well as the more commonly needed verniers in each system. Operation: After once adjusting machine for a particular type of

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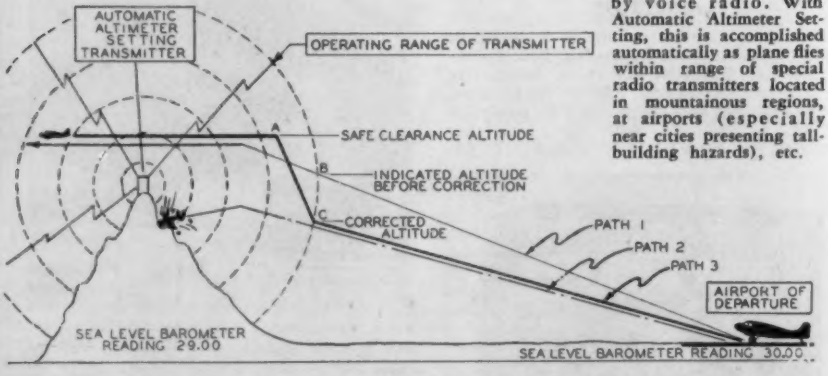
ruling job, operator merely clamps workpiece in position and throws starting handle. Ruling process is thereafter completely automatic, lines of scale being of whatever length, width, depth, spacing, and pattern the operator previously selected. When last line has been ruled, machine stops automatically with ruling tool away from work so that operator may replace the finished piece with a new blank and restart the cycle.—*The Gaertner Scientific Corp. 1201 Wrightwood Ave., Chicago 14, Illinois.*

Please mention number 709 when filling out card

Altimeter Automatically Compensated for Local Barometric Pressure

New "Automatic Altimeter Setting" is a ground radio-telemetering and airborne-altimeter pointer-reset system developed to aid air traffic control and instrument flying efficiency, lessening danger of mid-air collisions between planes, crashes into mountain tops, high buildings and other obstructions, and landing accidents during inclement weather. System comprises (1) new type of altimeter in planes and (2) special transmitters on ground. Altimeter automatically corrects itself for barometric pressure changes as plane flies within range of combination barometers and radio transmitters located at ground stations in mountainous regions, at airports, etc. These transmitting stations are compact lightweight radio transmitters actuated by a ground altimeter. They are self-operative and can easily be combined with existing radio range stations. An automatic cut-out device prevents confusion when an airplane is flying within the signalling range of two ground stations: device automatically cuts out weaker signal. Correct altimeter setting is extremely important for two reasons: (1) If it is neglected, altimeter may misindicate by as much as 1000 feet and create an extremely dangerous situation. (2) For traffic control: blind-flying airplanes are assigned definite altitudes by Air Traffic Control and if an airplane varies more than 100 feet from the assigned altitude, a traffic hazard is created. At present, with voice radio system, ground operator gives pilot correct setting (which is a four-digit number such as "three-zero-five-three") by pronouncing this number over his radio. Pilot must hear number and remember it long enough to manipulate his altimeter to obtain correct reading. Sources of error in this procedure are considerable. In new system, each ground altimeter sends out its own altimeter setting continuously in the form of a coded radio signal; airplane's altimeter receives this signal, automatically decodes it and sets itself in accordance with it. Announcement of new "Automatic Altimeter Setting" points out that it would eliminate one further aviation hazard at present difficult to deal with: tendency of an altimeter to give incorrect readings when air temperatures aloft are unusually high or low, compared to the "standard conditions." Thus, an airplane flying over Rocky Mountain regions might obtain the latest altimeter setting from an airport located in a valley (say 3,000 feet above sea level). This setting would be correct if pilot intended to land at the valley airport, but at his altitude (say approx. 12,000 feet) this setting is not necessarily correct: if the ambient air is abnormally cold at that altitude, pilot may think he is flying at 12,000 when he is actually flying at, say, 10,500 feet. This abnormal-air-temperature error can be entirely eliminated by placing Automatic Altimeter Setting ground stations upon mountain tops along the airways. *Operational checks:* Two provisions enable pilot to make sure the system is operating properly: (1) He may manually set his altimeter to any arbitrary figure. If system device is working correctly, altimeter returns itself to its original setting. (2) Pilot can feed his own altimeter a coded signal which represents "29.92," the altimeter setting which represents standard atmospheric conditions. In other words, pilot "fools" his altimeter into believing such a signal has been sent to it from the ground. If system is functioning properly, altimeter immediately sets itself to "29.92." Then, when pilot ceases to give this check signal, altimeter returns to

Barometric scale, visible through window at right, is adjusted by knob at bottom and can be set to any pressure level within scale range. With present method, to travel any distance, instrument must be adjusted manually during flight as notices of barometric pressure changes are available by voice radio. With Automatic Altimeter Setting, this is accomplished automatically as plane flies within range of special radio transmitters located in mountainous regions, at airports (especially near cities presenting tall-building hazards), etc.



Pilot plans to fly Path 1, having set his altimeter according to sea-level barometric reading at airport of departure.

With only airport setting, pilot flies Path 2. Sea-level barometric pressure gradually drops as plane approaches mountain; altimeter reads higher than it should and plane crashes into mountain.

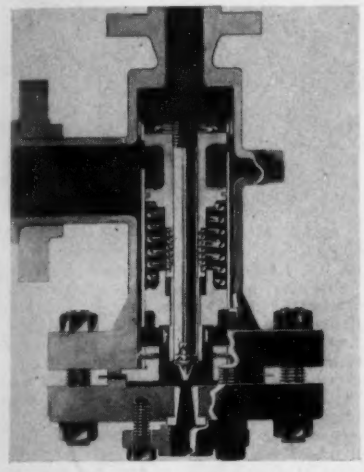
With automatic altimeter setting system, pilot follows Path 2 until plane comes within range of system's automatic transmitter. Here, airplane's altimeter receives correct setting signal by radio and automatically adjusts itself: altimeter pointer moves from indicated altitude *B* to actual corrected altitude *C*. Noting that he is at a lower altitude than that of his intended course, pilot climbs to safe clearance altitude *A*, Path 3.

correct reading in accordance with nearest ground station. *Coding Method:* A four-digit figure from each ground altimeter station must be expressed by a radio signal in such a manner that the airborne altimeter can "read" and "understand" it and set itself accordingly. Method tentatively selected is to radio an audible musical note of definite pitch. Loosely speaking, a high C would mean an altimeter setting of 28.60; A low note might mean 31.10. Airplane's altimeter contains an audio frequency analyzer which measures pitch of incoming signal precisely and then causes the altimeter to set itself accordingly. — *Kollsman Instrument Div., Square D Co., Elmhurst, L. I., N. Y.*

Please mention number 710 when filling out card

Automatic Recirculating Valve

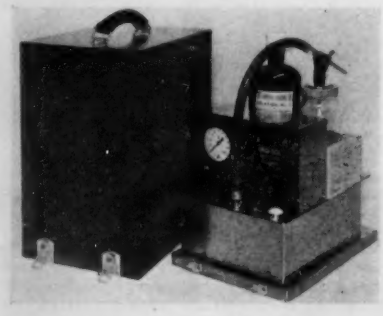
New Recirculating Valve prevents centrifugal pump failures resulting from insufficient flow of fluid through pump. It is operated from the fluid flow and is designed to by-pass minimum quantity of fluid required to eliminate pump overheating. As quantity of fluid passing through pump increases, by-pass quantity is automatically throttled and reduced to zero when pump output is sufficient to prevent pump failure. Valve may be installed in existing pump piping by removing any convenient elbow in discharge piping upstream of all checks and stops.— *Hammel-Dahl Co., 243 Richmond St., Providence 3, R. I.*



Please mention number 711 when filling out card

Cleaning Kit for Instrument Parts

New "PC-2 Portable Precision Cleaner" will chemically clean ball bearings, jewel bearings, optical mirrors, gages, measuring and recording instruments. It utilizes "Eng-Sol Method." Compressed air at 80 lbs./in.^{2} is passed through a ceramic filter and thermostatically controlled heater. Combined with a triple-distilled chlorinated hydrocarbon, this pre-treated air bombards the surface to be cleaned: high-velocity particles of solvent are driven into surface pores,



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Measures only 18"x 9"x 8", yet accommodates up to 12 channels and gives permanent record on paper or film 6" wide by 100 feet. Interchangeable galvanometers available in natural frequency from 200 to 10,000 cycles per second to a sensitivity of 50 milliamperes per millimeter at one meter.

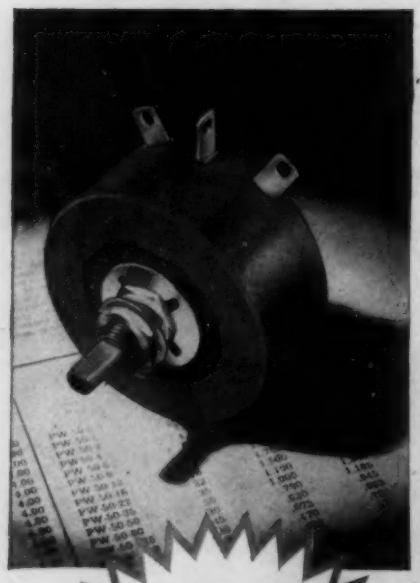
Automatic features: record length control; record numbering device; and time coordinate device which produces time lines clear across the record, quickly adjustable to either 1/100 or 1/10 second spacing. Viewing screen permits simultaneous viewing and recording.

Performance plus portability makes this instrument indispensable for field testing where accuracy and ease of control are imperative.

DELIVERY — 60 to 90 Days

●Write for bulletin SP-167. Hathaway Instrument Co., 1315 S. Clarkson Street, Denver 10, Colorado

Hathaway INSTRUMENTS



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Wire winding on insulated metal core and imbedded in cold-setting inorganic cement for maximum heat radiation even at fractional settings.

Smoother turning rotor because of properly tensioned support on collector ring and contact on winding.

Graphited-copper contact shoe in cradle arm contacts both winding and collector ring for short-path conduction.

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dissolving soluble matter. Air blast drives out insoluble material. Solvent is used only once, eliminating the possibility of leaving a film of oil or grease. Dirt and lint are also easily removed. Gaging to 0.000001" is possible after cleaning with "Eng-Sol Method." Sprayer is precision machined and laboratory calibrated to deliver an atomized spray. "Eng-Sol" solvent cannot burn nor explode. Kit is available for permanent table installations.—*Passaic Analytical Laboratories, Inc., 228 Aycrigg Ave., Passaic, New Jersey.*

Please mention number 712 when filling out card

Appliance Temperature Tester

New "Model 60-JRT," is designed for rapid check of operating temperatures of refrigerating equipment and ovens of gas or electric ranges. It checks four cold zones

and two heat zones simultaneously. It gives continuous readings outside the equipment being checked, so that operator can follow results of adjustments without opening doors. It measures temperatures from −100°F. to 80°F. as a resistance thermometer; from 0° to 600°F. as a thermocouple millivoltmeter with bridge compensation for ambient temperatures. Also measures line voltage from 0 to 300 volts a.c.—*J-B-T Instruments, Inc., New Haven 8, Conn.*

Please mention number 713 when filling out card

Insulation Tester with VTVM

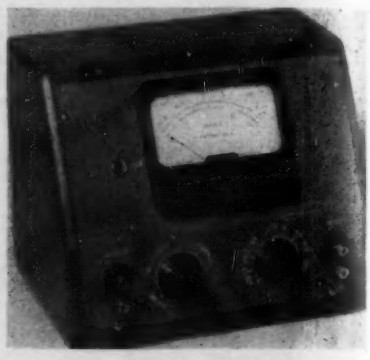
New "Model 665A" Insulation Tester is called the "Billionaire" in recognition of insulation resistance range up to 10 billion ohms. In addition, instrument includes a vacuum-tube voltmeter, ohmmeter and "capacitymeter," covering 29 measurement ranges for practically every laboratory or service testing job. Indicator is 8" size, is accurate to 2% at full scale. Automatic

line voltage check is said to provide a-c. as well as d-c. regulation to assure accuracy and stability. An automatic ohmmeter battery check maintains accuracy of low-range ohmmeter by warning operator when to replace battery. The "Billionaire" measures 9¾" × 12½" × 6", weighs 13 lbs. complete in a metal case with 4 leads, ready to operate.—*Radio City Products Co., Inc., 127 W. 26th St., New York City.*

Please mention number 714 when filling out card

Vacuum-tube Voltmeter

New "Model 45 Electronic Voltmeter" is a highly stable amplifier type of voltmeter with a logarithmic indicator. A range of

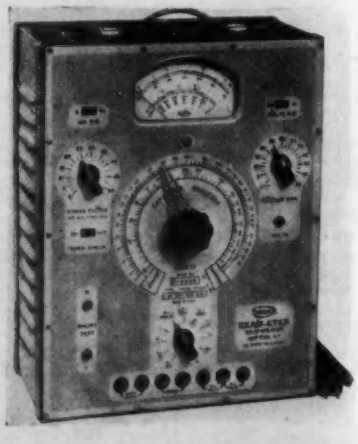


0.0005 to 500 volts at frequencies from 7cps. to 1.6Mc + 2% makes instrument suitable for all voltage measurements in the vibration, audio, supersonic and broadcast frequency bands. Input impedance of 5 megohms and 15 mmf. insures least possible disturbance. Complete range is covered by 6 switch positions. Output measurements can be made on low-level microphones and pick-ups. Db scale is linear. Line voltage variations from 105 to 125 will vary the readings at all frequencies within the specified range by less than + 1%.—*Instrument Electronics, 253-21 Northern Blvd., Little Neck, L. I., N. Y.*

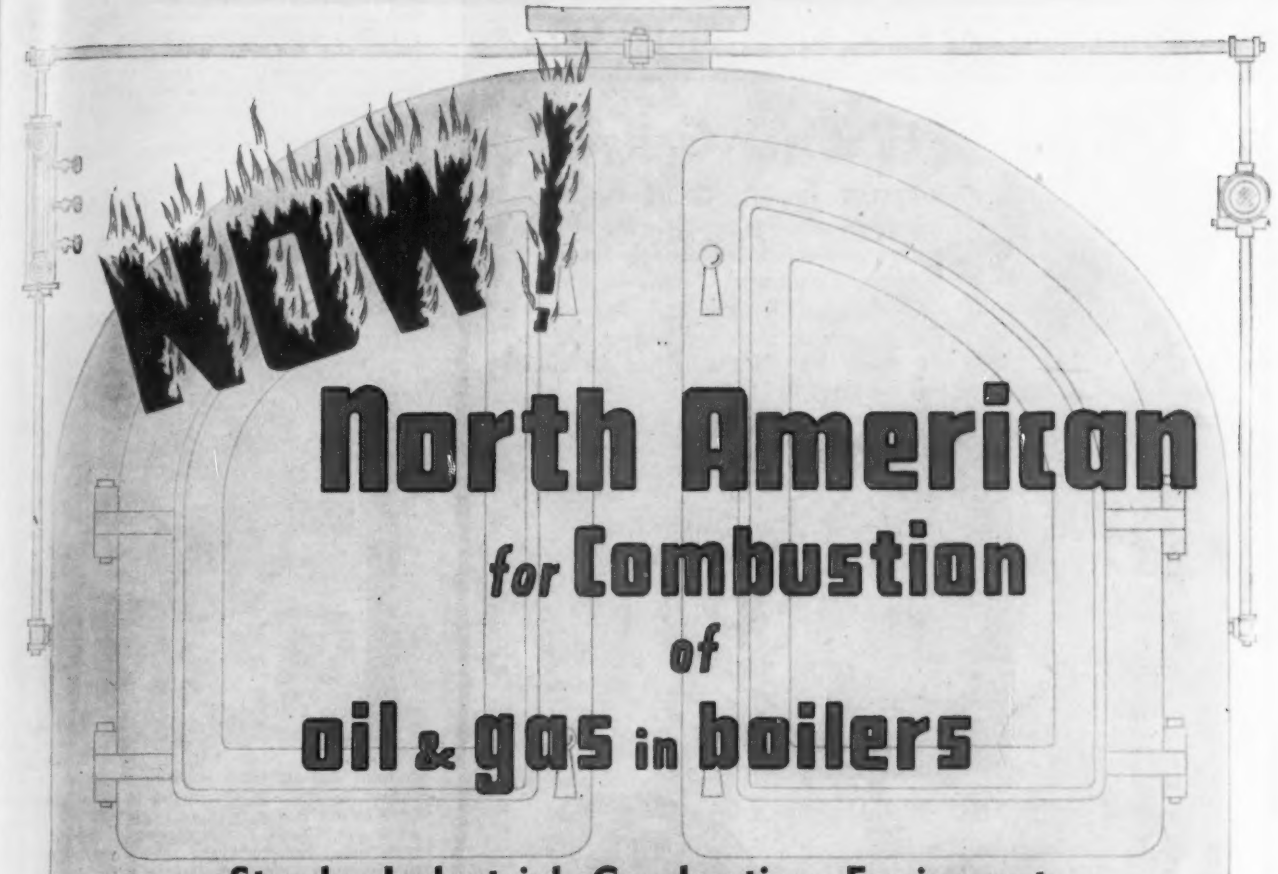
Please mention number 715 when filling out card

Capacitor Analyzer

New "Model CF Exam-eter" features patented "Quick-Check" oscillator circuit for spotting intermittent, open-circuited and



short-circuited capacitors without necessity of unsoldering them from electrical circuits. It contains a d-c. bridge to check capacitances from 10 mmf. to 2000 mf. and resistances from 100 ohms to 7.5 megohms. Capacitor power-factors up to 55% are read on an auxiliary bridge scale. The 4½" indicator is also used to measure electrolytic capacitor leakage currents under rated voltage from a self-contained continuously-adjustable d-c. voltage supply. Extra test



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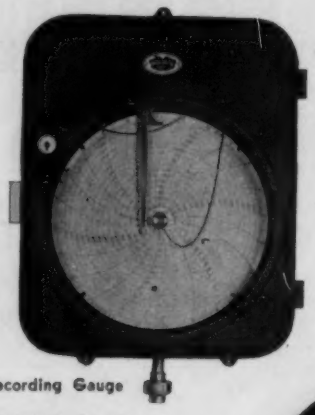

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jacks permit overload-proof external vacuum-tube-voltmeter measurements up to 600 volts d-c. and 50 volts a.c. An electronic test circuit supplements the bridge for measurements of capacitor insulation resistance up to 10,000 megohms.—*Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y.*

Please mention number 716 when filling out card

Vacuum-tube Voltmeter

New "Model 668" is an a-c. and d-c. "vacuum tube volt, ohm and capacitymeter" designed to speed production testing. Line

voltage adjustment, multiple resistors accurate to 1%, an ohmmeter battery under load to determine need of replacement, and a 40,000,000 to 1 measurement ratio for the "capacitymeter" are said to contribute to precision operation. Safety is assured by an easily replaced line fuse, thorough shielding and elimination of danger of shock. Instrument cannot be damaged by using a low range on high-voltage readings.—*Radio City Products Co., Inc., 127 W. 26th St., New York City.*

Please mention number 717 when filling out card

Insulation Resistance Tester

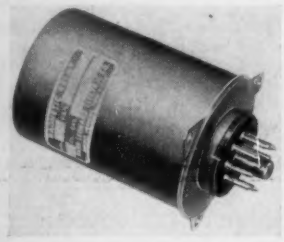
New "Ideal Insulation Tester" is designed for checking insulation resistance in a-c. and d-c. equipment. It is self-contained and ready for instant use anywhere. There are no batteries or external power supplies, no brushes or commutators: necessary power is provided by a small internal hand generator which is operated by a slowly-turning crank. (Crank can be turned in either direction.) Correct testing voltage is indicated by two small button lights that glow at 500 volts d.c. When crank is turned faster than necessary, an electronic voltage regulator controls voltage so that a true

reading is obtained. Test range is 0-100 megohms; Case, lightweight two-piece aluminum; Indicator is d'Arsonval type; Test leads, 10' long; Dimensions, 3⅝" × 6" × 3¼" high; Weight with leather carrying case, 3½ lbs.—*Ideal Industries, Inc., 1415 Park Ave., Sycamore, Illinois.*

Please mention number 718 when filling out card

Midget Plug-in Relays

New hermetically-sealed plug-in relays are designed for a-c. or d-c. operation in small radio transmitters, aircraft control



circuits and other applications where space is limited. Completely encased in a cylindrical can with standard octal plug base, these midget type relays provide excellent protection against adverse atmospheric conditions. They are available in contact combinations to double-pole double-throw with a-c. contact ratings (at commercial frequencies) of 4 amperes, from 0 to 115 volts and d-c. contact ratings of 0.5 ampere from 25 to 115 volts. They are vibration-resistant to 10 *G* and are provided with self-aligning silver-to-silver contacts—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Please mention number 719 when filling out card

High-frequency Vacuum-tube Voltmeter

New "Model 410A" High-frequency Vacuum-tube Voltmeter is a multi-purpose instrument for laboratory and production-line use. It measures a-c. voltage from 20 cps. to 700 Mc., d-c. voltage at 100 megohms input impedance, and resistance from 0.2 ohms to 500 megohms. For making a-c. measurements a special low-capacity probe is employed which incorporates a new diode especially developed by Eimac for this in-

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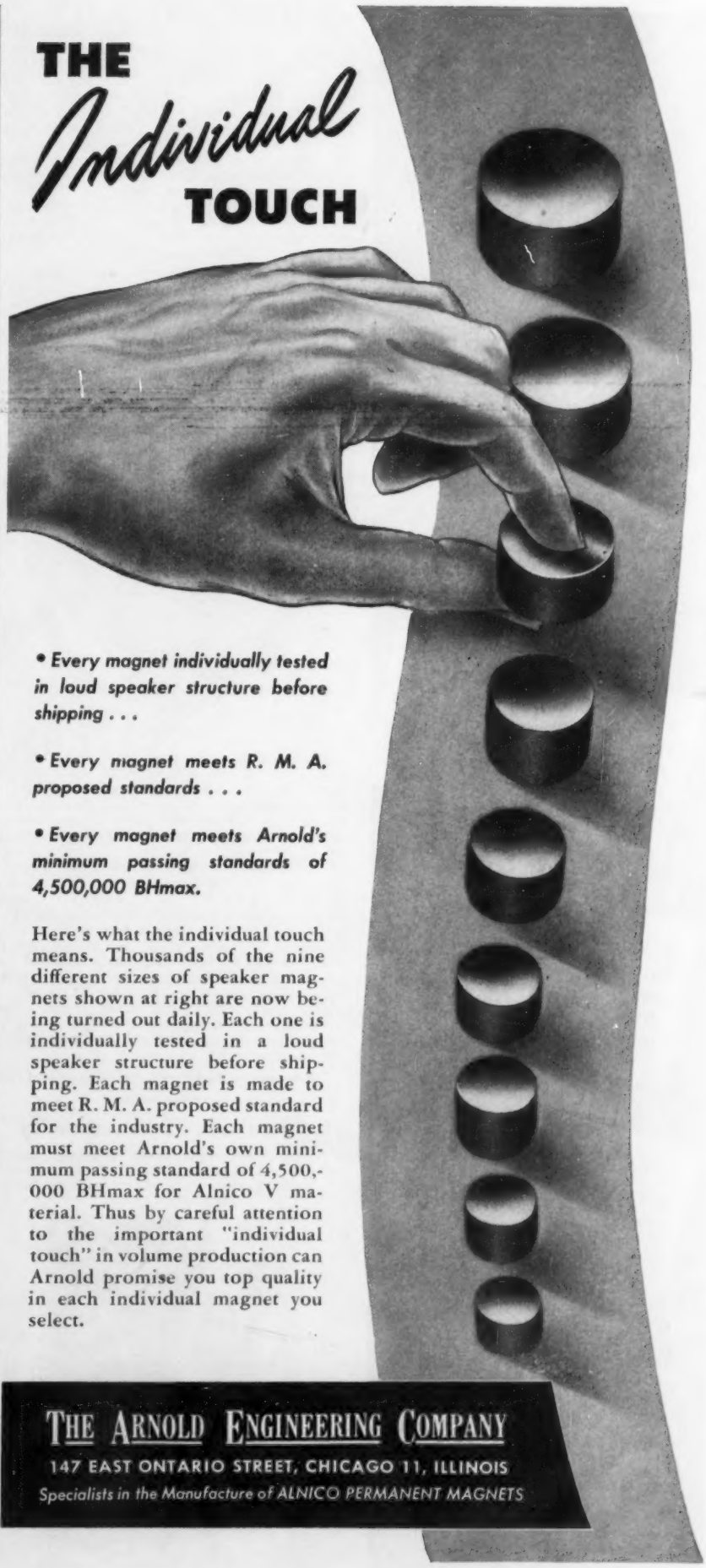

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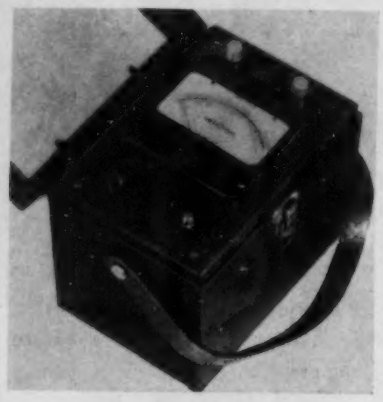
strument. Input capacitance is 1.3 mmfd; input resistance is 6 megohms below 10 Mc., less at higher frequencies owing to dielectric losses. On a.c., "Model 410A" reads 1 volt full-scale to 300 volts full-scale in 6 ranges. D-c. measurements may be made from 1 volt full-scale to 1000 volts full-scale in seven ranges; input impedance for d-c. measurements is 100 megohms for all ranges. For making a-c. measurements in low impedance circuits, the probe may be stored in a compartment in the instrument and connections made to binding posts on the front panel. Overloads will not damage the instrument.—*Hewlett-Packard Co., Palo Alto, Calif.*

Please mention number 720 when filling out card

Insulation Resistance Tester

New "Model 261 Vibrotest" is a portable self-contained insulation resistance-measuring instrument, testing to 50,000 meg-

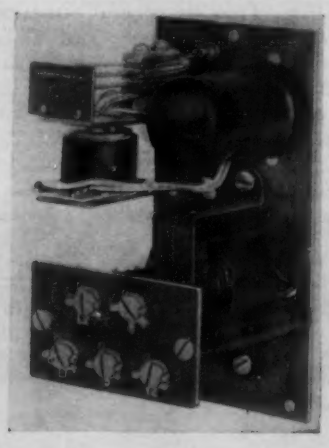


ohms (center scale 1200 megohms). It is said that utmost accuracy is insured by hand-stepped scale, calibrated against known standards of resistance. Instrument has a high voltage regulator in the measuring circuit. It is equipped with capacitor charging circuit to facilitate faster testing of capacitors or capacity circuits. "Model 261" has its own power supply, instantly available. Two No. 6, 1½-volt dry cells provide ample power of 500 volts. Instrument is thoroughly tested and checked for extremes of temperature variations, from —40° to 140°F. It is effectually guarded to eliminate stray leakage, and for operation in extreme humidity. "Model 261" is compactly housed in weatherproof metal case with carrying strap. Size 8⅞" × 6" × 8¼". Weight 17½ lbs.—*Associated Research, Inc., 231 So. Green St., Chicago 7, Illinois.*

Please mention number 721 when filling out card

Cold-cathode Thyratron Relay

New "Electronic Relay" utilizing new principle—the hot cathode thyratron—may be used in electrical control circuits with



advantage over ordinary vacuum-tube and cold-cathode devices. Principal characteristics are: (1) Snap acting; (2) High load contact capacity; (3) Trips by either external contact carrying 3 microamperes; or any external circuit whose value drops to 1 megohm pure resistance. Applications are: (1) In photocell circuits, for control of motors, valves, alarms, etc.; (2) Motion and limit control within microinches; (3) Converting delicate contact-making instruments into positive control devices without causing arcing or welding of electrodes; (4) Liquid level control where electrodes may be immersed in a tank. Operation is from 110 v., 60 cy. a.c. Switching action is SPDT, or up to 4PDT for loads to 12 amps., 110 v., a.c. non-inductive. Mercury contacts are supplied for contacting loads to 30 amps. While design is suitable for mounting unenclosed, general-purpose as well as dust-tight enclosures are available. —*Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.*

Please mention number 722 when filling out card

Copper Oxide Rectifier

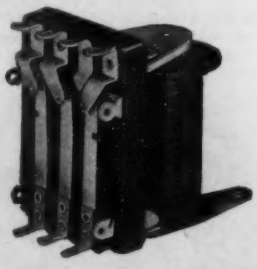
New "Model CO12D4F" copper oxide rectifier is conservatively rated at either 6 volts a.c., 4½ volts d.c., or 35 milliamperes

d.c; is designed for control applications. Unit is completely sealed, with a special plastic compound, against moisture and corrosive vapors. Pre-soldered lead wires prevent damage from overheating during assembly.—*Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn.*

Please mention number 723 when filling out card

Two- and Three-pole Relays

New "Series 16" line of two-pole and three-pole relays feature shockproof action under stress as high as 10*G*. Relay is de-

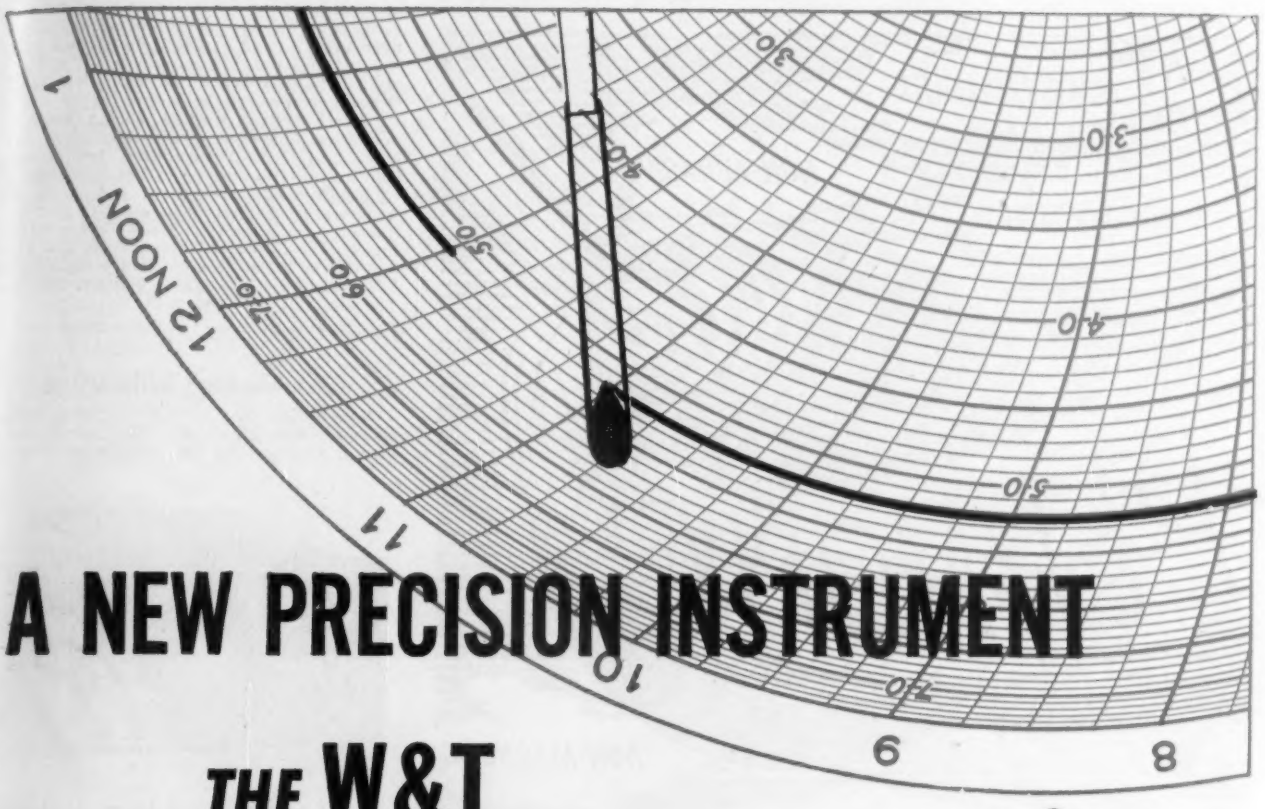


signed so that actuating armature is insulated from contact arms by a Bakelite link. This feature reduces chatter and provides a dielectric strength of 1500 volts between all contacts and ground. Rated for 2 watt operation, coil will dissipate as much as 4 watts in continuous operation without overheating. Any two- or three-pole contact combination is available. The contacts are rated 2 amperes at 100 watts. A coil may be selected for any d-c. voltage between 0.5 and 150 volts, any a-c. voltage between 3 and 500 volts. Approx. dimensions, 2" long × 1 5/16" wide × 1¾" high. Weight, approx. 4 ounces.—*Kurman Electronics Corp., 35-18 37th St., Long Island City 1, N. Y.*

Please mention number 724 when filling out card

A-c. or D-c. 1-kw. Relay

New "Series 41" Relay has approximately same sensitivity as maker's "Type 4" relay, while eliminating a number of features not needed on many high-volume applications. Simplified construction allows makers to offer a serviceable unit at a low price. Small size and light weight are among fea-



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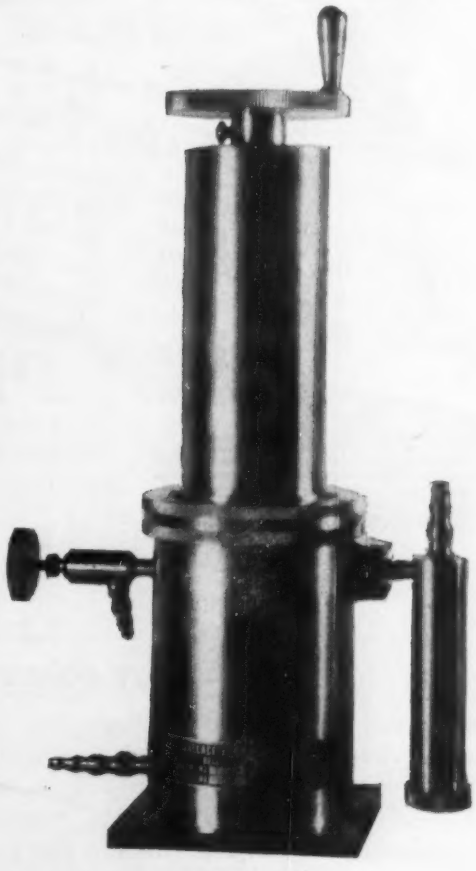

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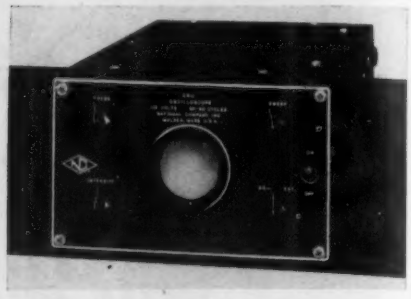
tures. Plug-in type weighs 3 oz. and measures 1½" × 1½" × 1⅞"; unenclosed relay weighs 2⅝ oz. and measures 1" × 1½" × 2⅜" long including mounting plate. Other features are beryllium-copper armature and contact springs, spring reed-type armature hinge with low-reluctance gap, and, and high-permeability low-residual iron parts. Minimum input requirements are 20 milliwatts for d-c. types and 0.1 va. for a-c. types. Contacts are *s*-p.d-t. and will handle, with somewhat more than marginal input power, up to 15 amperes on low voltage d.c. or 1 kw. incandescent lamp load at 115 volts a.c.—*Sigma Instruments, Inc., 388 Trapelo Rd., Belmont, Mass.*

Please mention number 725 when filling out card

Cathode-ray Oscilloscope

New "CRU Oscilloscope" includes built-in power supply and input controls. A panel switch also permits use of built-in 60-cycle



sweep or external audio sweep for securing the familiar trapezoid pattern for modulation measurements. The 2AP - 1A with a 2" screen and popular 6X5 rectifier are used. New oscilloscope is supplied in a table model but may be converted to rack model by addition of a rack panel. It is finished in black wrinkle. Because of its sensitivity, amateurs and experimenters will find the new instrument a valuable tool in adjustment of equipment, it is said. Oscilloscope is said to have proved serviceable under adverse climatic conditions.—*National Company, Inc., Malden, Mass.*

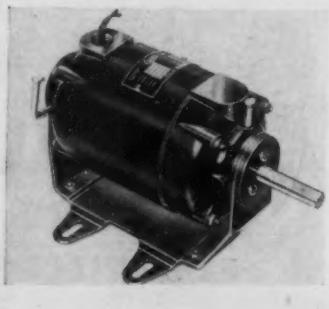
Please mention number 726 when filling out card

Capillary Pen for Recorders

New capillary pen for three-pen rectangular industrial recording instruments is a single tube type, its end in contact with instrument chart swaged to a smaller diameter, while capillary itself is less than half diameter of earlier design. A smaller tube minimum pen friction and smooth action even where instrument has a measuring system of extremely low actuating force. restricts ink flow, eliminating flooding. O. D. has been reduced to about half original size. Smaller area, combined with other constructional features, is said to contribute to *Brown Instrument Co., 4482 Wayne Ave., Philadelphia 44, Penna.*

Instrument Motor

New "Type KS-837 Ostermotor" is recommended for continuous-duty applications where quiet vibrationless operation and long



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Design and Development Engineer. Must have had experience in design, development and manufacture of: (1) pressure elements including helical, spiral and Bourdon-tube; (2) all conventional temperature systems such as gas-filled, vapor pressure, mercury, etc.; (3) mountings, pivots, etc. College graduate preferred but please supply all revelant details as to education, positions held, design achievements, etc.

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life are essential. It delivers up to 1/10 h.p. at 1725 r.p.m. It is a totally-enclosed split-phase induction, continuous-duty model, operating on 115 volts, a.c. Bronze sleeve bearings are grooved for best oil distribution and oversize felt oil retainers feed oil to shaft through two spring tension wicks at each bearing. Resilient neoprene mountings are not affected by oil or grease. Flange mounting is also available. Finished in black enamel. Length over bearings 8⅜", housing diameter 4²⁷/₆₄, weight 15 lbs.—*John Oster Mfg. Co., Racine, Wis.*

Please mention number 728 when filling out card

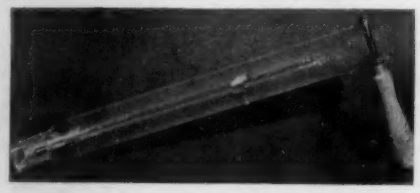
Hot Transformer Alarm

New "Thermalarm" gives a signal when a transformer is or has been operating above a predetermined limit. Housed in a Melmac plastic case, 3⅜" long by 1 1/16" wide by 1 1/16" deep, unit has a die-cast aluminum base which projects from back and acts as heat conductor. This case completely encloses a thermal element which controls a latch and releases a flag when safe operating temperature is exceeded. Spring-actuated flag, normally in downward position, flies up and presents a brilliant red surface large enough to be visible from ground level. Unit can be preset to actuate the latch at any point between 100°F. and 200°F. Device weighs 3 ozs., is reported as simple to apply, being held to transformer case by an adhesive.—*Eastern Specialty Co., 3617 North Eight St., Philadelphia 40, Pa.*

Please mention number 730 when filling out card

Wet- and Dry-bulb Psychrometer

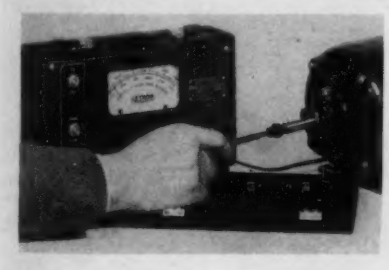
New "No. 1170" sling psychrometer utilizes wet- and dry-bulb principle and is whirled in usual manner, but its thermometers are enclosed in a transparent plastic tube which, it is said, "will usually withstand dropping." Whirling results in an air blast through tube, cooling wet bulb as rapidly as in an ordinary sling psychrometer.—*Laboratory Specialties, Inc., 144 South Wabash St., Wabash, Indiana.*



Please mention number 729 when filling out card

Synchronous-speed Tachometer

New Synchronous-speed Tachometer for 1800 and 3600 rpm. is available in three models as follows: "Type 48A" for speeds above synchronism (1700 to 2200 and 3400 to 4400 rpm.); "Type 48B" for speeds be-



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AIR MILES	2 lbs.	5 lbs.	25 lbs.	40 lbs.	Over 40 lbs. Cents per lb.
149	$1.00	$1.00	$1.00	$1.23	3.07¢
349	1.03	1.18	2.30	3.68	9.21¢
549	1.07	1.42	3.84	6.14	15.35¢
1049	1.17	1.98	7.68	12.28	30.70¢
2349	1.45	3.53	17.65	28.24	70.61¢
Over 2350	1.47	3.68	18.42	29.47	73.68¢
INTERNATIONAL RATES ALSO REDUCED					

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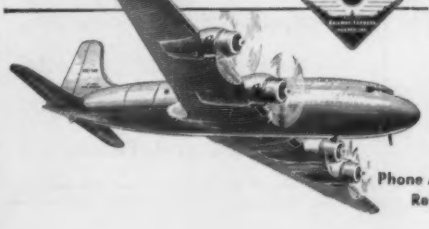

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Standing only 37" high, weighing but 137 lbs., the Dillon Universal Tester checks wire, copper, aluminum, fabrics, steel, etc. for tensile, transverse, compression and shear strengths. Available in 7 capacities, with interchangeable dynamometers, the Universal will test from 0 to 10,000 lbs. Special gripping jaws are made for every requirement.

The Universal Tester may be either hand or motor operated. No special training is needed to record accurate results instantly on the dynamometer. It is compact, simple, inexpensive—designed for small shops and plants everywhere.

Tests prove that workers, too, undergo strain and nervous tension on the job. That's why many factories urge workers to chew gum. Workers can chew Wrigley's Spearmint Gum right on the job—even when hands are busy. And the act of chewing helps relieve monotony—helps keep workers alert, thus aiding them to do a better job with greater ease and safety.

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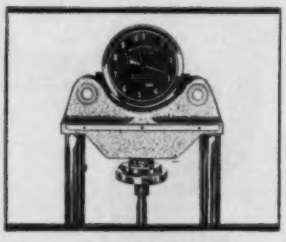


Interchangeable Dynamometer

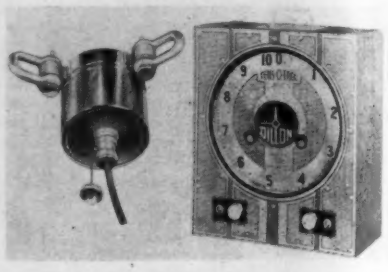
AA-78

low synchronism (1500 to 2000 and 3000 to 4000 rpm.); "Type 48C" giving equal spread above and below synchronism (1550 to 2050 and 3100 to 4100 rpm.). Special ranges are available on request. Instrument employs no flyballs or gears, no generator; Head is a contact-making mechanism (operated by rotation of spindle) periodically charging a capacitor through a d-c. milliammeter which indicates average current. Scales are exactly linear; accuracy is 0.25%. Dimensions: 10¼" long, 6¼" high, 4" deep; Weight: 8½ lbs. New tachometer requires an extremely low torque (0.25 ounce-inch) and therefore does not disturb the system being tested.—*Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.*

Please mention number 731 when filling out card

Remote-indicating Dynamometer

New "Tens-O-Trol System," electric remote tension and weight indicator, combines maker's dynamometer and highly-responsive

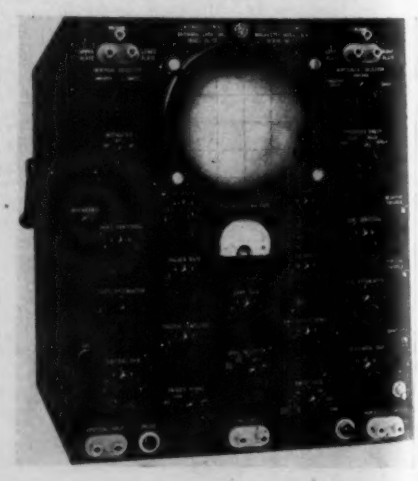


self-synchronous motors. Repeater stations are 12" wide, 14" high and 5" deep; weigh 10 lbs. Dial is 9½" diam. with 1" figures. Pressure beam in "Tens-O-Trol" requires a deflection of 0.04" for full 360° scale reading. When master transmitter deflects, repeater stations duplicate with an accuracy of 0.5% or better. System requires 12 volts d-c. for operation. Extreme temperature changes have no appreciable effect. All dynamometers can withstand a 100% overload and take a 25% overload without injury to calibration.—*W. C. Dillon & Co., Inc., 5410 W. Harrison St., Chicago 44, Ill.*

Please mention number 732 when filling out card

General-purpose Oscilloscope

New "Model OL-15" five inch oscilloscope is said to incorporate latest circuits and to have been designed for versatility of operation, dependability, minimum weight and bulk, and faithful presentation of high-harmonic-content waves. Response curve of vertical amplifier is linear and without positive slope from 10 cps. to well over 4 Mc. and has transient response such that a 100-kc. square wave, with rates of rise and fall of the order of 400 volts per



WANTED: Instrumentation and Control Engineer to select and specify equipment for petroleum refineries. Knowledge of oil refinery practice and requirements essential. Mechanical or chemical engineering education and background desirable. Opportunity for advancement. Location, New York City. Box 112, Instruments Publishing Company, 1117 Wolfendale Street, Pittsburgh 12, Pa.

PROJECT PHYSICIST WANTED

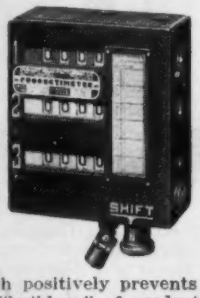
Graduate from an Accredited Engineering School with a major in Physics and Mathematics. Age limit 25-30. Must be capable of organizing and directing Research Projects. Write in full to Dept. "P", P. O. Box 420, Lancaster, Penna.

microsecond, is faithfully reproduced. Horizontal amplifier response extends linearly from 10 cps. to over 1 Mc. to accommodate any desired type of externally-generated sweep voltage. Sawtooth sweep range is from 5 cps. to 500 kc. with synchronizing sensitivity permitting synching and viewing 10-Mc. rf. sine waves. Triggered sweeps of 1, 4, 20, and 200 microseconds per inch may be inaugurated by the internal trigger generator or by external pulses. Sweeps and internally-generated trigger are phasable with respect to each other so that sweeps may be adjusted to occur before or after output triggers by varying degrees. These sweeps are also useful in viewing periodic phenomena of various types. Direct connections to all cathode-ray tube control elements can be made on front panel. Cast aluminum bezel over cathode-ray tube screen assists in preventing glare and provides convenient means of changing ruled masks, color filters and viewing aids. Total weight of instrument, including self-contained power supply, is less than 85 lbs. Dimensions: 15¾" × 12¾" × 19¾".—*Browning Laboratories, Inc., Winchester, Mass.*

Please mention number 733 when filling out card

Pick Counters

New two- and three-shift Pick Counters designed to meet varied requirements of mill men. A special feature is shutter mech-

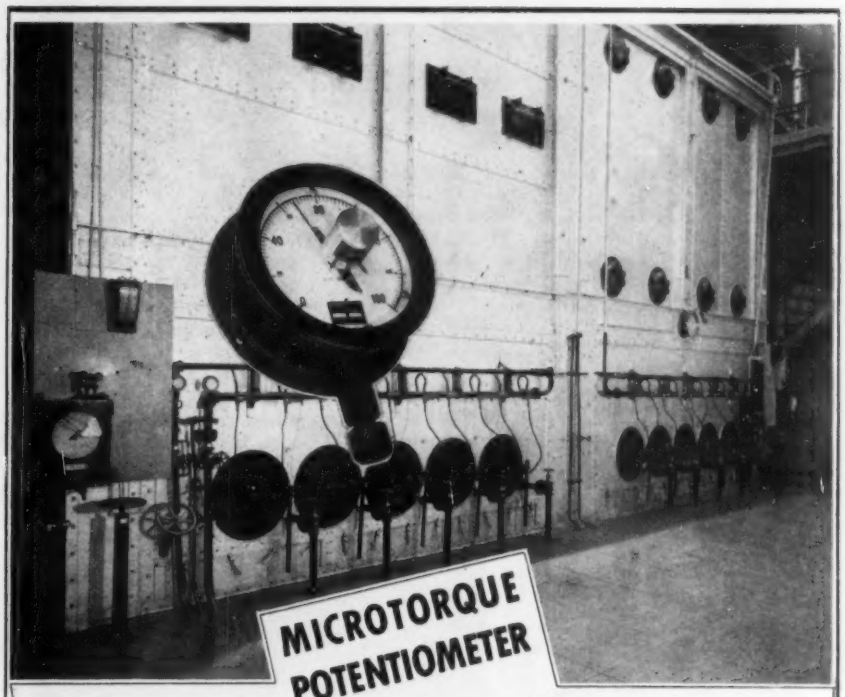


anism which positively prevents any falsification or "build up" of production figures. Any such attempt results in shutter closing and concealing figures. Other features: resettable from either side; center drive to fit any loom without special attachments; interchangeable for right or left-hand looms; shift knob made resettable or nonreset in three- and four-figures capacity; rustproof and dustproof.—*Durant Mfg. Co., 1914 N. Buffum Street, Milwaukee 1, Wisc.*

Please mention number 734 when filling out card

Time Counter and Automatic Timer

New "Type PTT-1 Precision Time Counter and Automatic Timer" is designed for accurate measurement and control of timed intervals and simultaneous operation of associated apparatus used in testing of engines, motors, or production machines. Time counter registers, in figures, time intervals up to 100 minutes (and repeat) to an accuracy of 0.001 minute. Operation is automatic for intervals of 0.1 minute and 1 minute; manual for any other period of time. Automatic operation for 0.1- and 1-minute intervals is obtained by means of a precision timer which starts and stops



MICROTORQUE POTENTIOMETER

Hundreds of remote control and position repeating problems are greatly simplified by the adaptation of *AUTOFLIGHT's tiny, ultra-low torque variable resistance units.

Ideal for take-offs from low torque indicating meters by simple yoke adaptation to the instrument pointer, for take-offs from bellows elements used in temperature, pressure, or flow measurements, as primary control elements in bridge type circuits to operate directly recorder-controllers, recording galvanometers, oscillographs, and polarized relays.

Characterized by large electrical outputs with small mechanical inputs, the MICROTORQUE can be attached to sensitive movements without causing excessive drag.

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FEATURES:

1. *Vibration-proof 4 to 55 cycles up to 6 G.*
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3. *Input torque less than .003 oz in.*
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5. *Linearity ½% or better.*
6. *Weight less than ¾ oz.*
7. *Size 1" x 1¼"*

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Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

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WANTED

The Tennessee Valley Authority has vacancies for electrical laboratory technicians in its Electrical Laboratory and Test Division located in Chattanooga, Tennessee.

These positions are classified as Electrical Engineer I with an entrance salary of $2770 based on a 40-hour work week schedule with opportunity for within-grade increases and promotion.

Candidates must have experience in the repair and calibration of delicate electrical instruments including a thorough knowledge of electrical measurements.

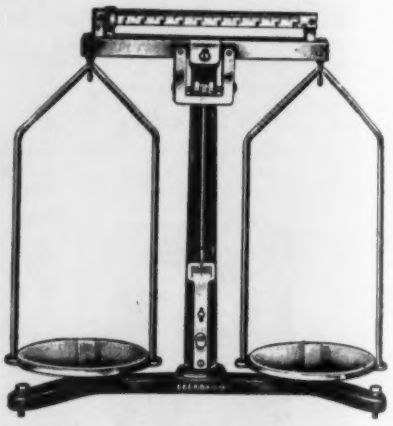
Interested persons should write the Personnel Department, Tennessee Valley Authority, Chattanooga, Tennessee.

the counter so nearly instantaneously that the interval is accurate to a few milliseconds. A double-pole double-throw relay is incorporated to operate fuel valves, revolution counters, recorders, motion-picture cameras or other devices simultaneously during the timed period. The time period may be created, accurately measured, and transmitted to other apparatus, or it may be received from other apparatus and measured by the time counter. Instrument requires a minimum of 10 watts of accurately-controlled 60-cycle frequency power and a total wattage of 40 to 45. Dimensions of front panel are 5½" × 8"; weight of instrument approx. 15 lbs.—*The Electric Tachometer Corp., Broad and Spring Garden Sts., Philadelphia 23, Penna.*

Please mention number 735 when filling out card

Laboratory Balance

New "Model A 3-770 Utility Laboratory Balance" is designed for weighing bulky samples where a capacity of 2 kg. and an

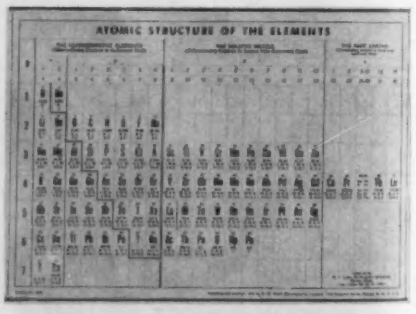


accuracy of 0.1 g. are required. It is designed for heavy duty without decreasing sensitivity. Beam is a departure from conventional type in that it combines rigidity with protection of knife edges and bearings from dust and mechanical injury. Beam has a single sliding weight and fixed scale, graduated to 10 g. in 0.1 g. subdivisions, eliminating use of weights smaller than 1 g. Bearings are agate; pans are 14 cm. in diameter of nickel-plated brass. Total height 42 cm. Pans are slightly concave; bows are 15 cm. wide and 30 cm. high. —*Eberbach & Sons Co., Ann Arbor, Mich.*

Please mention number 736 when filling out card

Atom-structure Wall Chart

New chart of atomic structure of the elements is based upon concept of the "differentiating electron." It was compiled

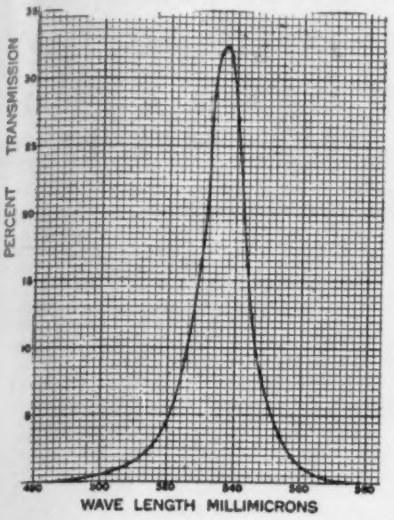


by Professor W. F. Luder of Northeastern and was written up in *Journal of Chemical Education*, Vol. 20, 1943, page 21. Chart is printed in 3 differentiating colors on heavy reinforced chart stock 42"x58", with double split rollers at top and bottom. It includes the two new artificial elements, Np and Pu. —*W. M. Welch Mfg. Co., 1515 Sedgwick St., Chicago 10, Illinois.*

Please mention number 737 when filling out card

Interference Type Optical Filters

New "Farrand Interference Type Filters" are available in the spectral range from 350 to 1200 millimicrons in 50 mm. squares and



in three series. "Series I" comprise filters offered individually or in sets spaced in 25 mμ. peak transmission intervals and isolate band widths of 15 mμ. "Series II" comprise line source filters; "Series III" comprise "Standardized" filters with exceptionally close tolerance ± 3 mμ at peak transmission and supplied for any wave band isolation desired by the user within the present available spectral range from 350 to 1200 mμ.—*Farrand Optical Co., Inc., Bronx Blvd. and E. 238th St., New York 66, N. Y.*

Please mention number 738 when filling out card

Dial Type Thermometer

New all-metal dial-type thermometer for indicating temperatures from 100°F. to 950°F. is provided with a slip-on handle

which protects operator's hand when instrument is in portable use. Handle can be easily detached when instrument is to be permanently mounted. Features include all-metal construction which gives maximum protection against vibration, shock, and rough handling; precision bi-metallic temperature element which has no pivots, mechanical linkages, or gears and is stated to provide sustained accuracy within 1% of scale range; designed to withstand momentary over-scale temperatures within 10% of scale range. Made with corrosion-proof stainless steel stem 3/16" O.D. and 5" free length, with only 2" immersion required to obtain accurate readings. Also available with ¾" O.D. stem having 9" free length.—*Bacharach Industrial Instrument Company, 7000 Bennett Street, Pittsburgh 8, Pa.*

Please mention number 739 when filling out card

To test over-all performance

SQUARE-WAVE GENERATOR

● This unit, generating its own frequency or synchronized from an external source, will be found invaluable in many fields. FM, AM and Television Broadcasting—Telephone and Telegraph Communications—Manufacture of Transmitting and Receiving Equipment and Parts.

● Many additional functions will recommend it for use in school and college research projects and in scientific laboratories.

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For additional information write: *Electronics Department, General Electric Company, Syracuse, New York.*

Electronic Measuring Instruments

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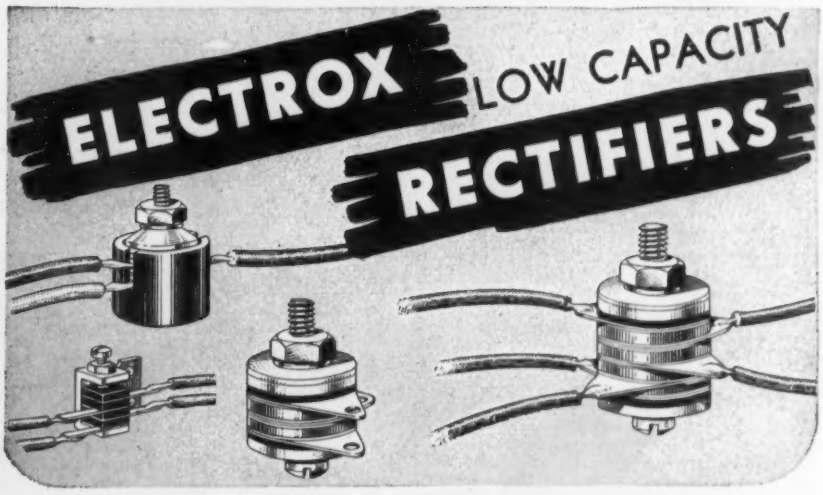

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SOCIETY OF AMERICA

National Instrument Conference and Exhibit

Over 1500 instrument men and engineers are expected to attend the First National Instrument Conference and Exhibit of The Instrument Society of America, which will be held in the Wm. Penn Hotel, Pittsburgh. September 16-20, 1946.

Albert Sperry, President of the Instrument Society of America, in urging attendance at the "Instrumentation for Tomorrow" Conference and Exhibit, pointed out that now is the time to make plans for the long-awaited day when industry will resume production free from all restrictions.

The General Chairman of the Conference, R. J. S. Pigott, has arranged a very interesting program consisting of 15 sessions covering the following subjects: Measurement and Automatic Control in Industry, Plant Instrument Department Practices, Inspection and Gaging, Scientific Measurements, Research in Instrumentation, Physical Testing, etc.

Paul Exline, Chairman of the Exhibit Committee, advised that up to July 1st, 95 manufacturers had made reservations and advised that they plan to show many new and improved instruments and controls perfected during the war.

INDIANAPOLIS

The regular meeting of the Indianapolis Technical Instrument Society was held June 4, 1946, at Purdue University Center.

Mr. D. O. Kocmich, of the Trimount Instrument Co., Chicago, gave a very fine talk on "New Electronic Instruments." He gave the circuit for an inductance bridge and the associated equipment to either indicate or record the degree of unbalance of the bridge. He described and showed a variety of pick-ups for the measurements of strain, pressure, etc.

—MORRIS UNDERWOOD, *Sec'y-Treas.*

LOS ANGELES

A very interesting meeting was held on June 4th by the California Section. A brief business meeting was held during which, Past President Wm. (Bill) Warren was elected as our member of the national Board of Directors.

Mr. Harry A. Fore, president of The Goldak Co., of Glendale, Calif gave a detailed talk on "Electronic Devices for Locating and Tracing Underground Pipes." His talk also touched on metal detectors, mine locators and other similar devices. Mr. Fore had a unique demonstrating unit.

—M. D. PUGH, *Sec'y*

NEWARK

The members of the New Jersey Section were guests of the Standard Oil Company's (N. J.) Bayway refinery on May 4th. A group of 85 visited the Company's aviation engine fuel test stand and inspected the full scale operation of a 1350-hp. engine.

The trip was conducted in two phases in which the group first inspected the test cell, engine and instrument control room. The engine was put through its paces and all the facilities were described by Mr. O. G. Lewis who is in charge.

Upon completion of the inspection trip, the group then assembled to have Mr. G. A. Martin explain the instrumentation for the cell. The amount of design and other work can be inferred from the fact that the instruments chart some 500 readings.

We are sure this meeting will go down as one of the highlights of the current season. We're for more inspection trips if they can be as well handled as this one.

—H. S. CLOSE, *Secretary*

NEW YORK

The New York Section, I.S.A., held its monthly meeting on June 17, 1946 at the Men's Faculty Club, Columbia University. Forty members and guests were present for dinner with eight additional members arriving later for the meeting.

Prof. C. F. Kayan, Section President, opened the meeting at 8:00. The Treasurer, E. E. Corbett, read a well prepared semi-annual report; and Vice President, H. L. Hildenbrand reported on the preliminary draft of by-laws for the Section.

President Kayan then introduced the speaker for the evening, Mr. A. L. Chaplin of the American Cyanamid Company, who gave a very interesting paper entitled "Some Problems Affecting Instrumentation in the Chemical Processing Industries." Mr. Chaplin explained the essential differences between batch and continuous methods of processing, mentioning where each was best suited as well as pointing out what type of measurements were needed in each case and where automatic control could be used to an advantage to obtain a uniform standard product. He also pointed out the necessity for the instrument engineer to help in the plant lay-out in order that the instrumentation may be integrated with the plant.

—CHARLES DANA COREY, *Sec'y*

NORTHERN INDIANA

The Northern Indiana Section of the I.S.A., held its May meeting on the evening of May 24 at the Lake Hotel in Gary, Indiana. Our original May meeting, scheduled for the 15th, was called off due to the inability of the speaker to appear at that time.

We were fortunate to get Mr. Albert F. Sperry to come out from Chicago and give us a good talk on the I.S.A. Mr. Sperry is President pro tem of the I.S.A., so we would have had difficulty in finding a more informed speaker on that subject. His talk dealt mainly with the structure of the I.S.A. and the purposes of each part of the structure. He also told us about the meeting at Detroit where much good work was done toward getting the organization rolling. He described in detail the Educational program, the Advisory Council of Instrument Users, the Standardization Committee, and the Instrument Manufacturers' Advisory Committee. His description of the coming exhibit in Pittsburgh, was heartening.

Mr. Sperry spoke quite informally and had our group relaxed in a very few minutes. When he was finished he left us with the warm feeling that we are a part of an important nation-wide organization, which the industry of this country needs urgently if it is to keep ahead in the technical world; an organization which is definitely on solid ground now and starting on the achievement of the purposes laid down in its constitution and by-laws.

—EDWARD WHITE, *Publicity Committeeman*

WAYNE COUNTY

At the June meeting of the Wayne County Section, Mr. Herb Barnum, formerly of Minneapolis-Honeywell, brought an electronic micrometer and gave a blackboard talk explaining its construction and circuits. This micrometer is sensitive to twenty-five millionths of an inch. It operates without perceptible pressure on the article being measured. Mr. Barnum then showed us the circuits and operation of a new electronic timer for fixing duration and frequency of electrical impulses.

The talk was concluded by a little chat on "Human Engineering." We learned some uncomfortable facts about nervous tension and mental breakdowns. There were some suggestions as to what should be done at home, and by the sufferer, and by employers, to make relaxation more beneficial.

—JOHN MAC PHERSON

Other Societies

KALAMAZOO

The Southern Michigan Instrument Society held its June 12 meeting in Galesburg, Michigan. Following the dinner, Mr. E. B. Bossart of the Bailey Meter Co. gave an illustrated lecture of the value of Coordinated Control in a Steam Power Plant. Mr. Bossart was introduced by Mr. Fred Brydges, of General Foods Corporation of Battle Creek, Michigan.

The meeting was attended by 32 men and 7 women.—KEN MEAD, *Executive Secretary*

SOUTH TEXAS

The regular meeting of the South Texas Instrument Society was held 11 June 1946 at the Central Power & Light Company's Meter & Repair Shop in Corpus Christi.

Mr. T. M. Hunt, First Vice President, presided in the absence of President B. F. Heye. Mr. J. B. McMahon of Republic Flow Meters Company gave a short talk on the National Instrument Society.

A very good amateur ventriloquist followed. The actors were Donald Duck and 10-year old Russell Schockler.

The history and organization of the Central Power & Light Company's meter testing and repair department were outlined by Mr. Floyd Salmons, and then Mr. M. D. Jester explained the "innards" and operation of electric meters of various kinds.

After Mr. Jester's talk, those present toured the shop in small groups and saw all phases of repair and testing of meters.

Refreshments were served to 35 members and 5 guests.

June 16, Father's Day, the South Texas Instrument Society held a barbecue at the La Gloria Corporation Cycling Plant near Falfurrias, Texas.

An excellent meal of barbecued beef, beans, fresh tomatoes, and watermelon was served to sixty members, wives, children and guests. All present extended thanks to J. P. Nielsen, Chester Wheless, and R. E. Denmead for the work they did in producing a first rate "outing."

After a short talk on the question of a cycling plant and the products produced, such as propane, butane, and gasoline, by Secretary Givens, a tour of the plant was conducted by J. P. Nielsen and Secretary Givens. —HOMER C. GIVENS, *Secretary*

PIONEER

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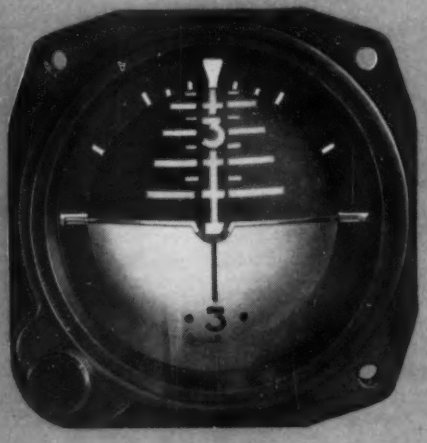
ATTITUDE INDICATOR



provides a continuous combined pattern of attitude indications through 360° of both roll and pitch

The Pioneer Attitude Indicator is designed to provide continuous positive indications regardless of the aircraft's attitude. In trimming accurately for straight and level flight, even the slightest changes from desired attitude are clearly indicated by movements of the dial against the reference marks.

Readings are made as a combined pattern of pitch and bank, rather than as separate readings. The Pioneer Attitude Indicator has a special gimbal arrangement which offsets gimbal lock effect, making this Indicator a truly non-spillable gyro—with long service life—as proved by millions of dependable operational hours in aircraft the world over. Operates on 26 volts, 400 cycle current, drawing only .18 amperes.

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I. S. A. SECTIONS

City, Section, and Secretary	Date and Place	Subject and Speaker
Baltimore, Md.; Baltimore Section, I.S.A., F. Ragan, Fuel Div., Beth. Steel, Sparrows Pt., Md.		
Charleston, W. Va.; Charleston Section, I.S.A.; M. B. Lorig, 1506 Virginia St., Charleston 1		
Chicago, Ill.; Chicago Section, I.S.A.; A. J. Butler, c/o IHC, 2626 W. 31st Blvd., Chicago		
Cleveland, Ohio; Cleveland Section, I.S.A.; A. J. McCullough, Minneapolis-Honeywell, 5005 Euclid Ave., Cleveland 3		
Cumberland, Md.; Cumberland Section, I.S.A.; Carl Lower, LaVale Rt. 1, Cumberland, Md.		
Detroit, Mich.; Detroit Section, I.S.A.; J. D. McCullough, Horace H. Rackham Bldg., 100 Farnsworth, Detroit 2		
Gulf Coast (Tex.); Gulf Coast Section, I.S.A.; O. D. Sanders, Neches Butane Co., Port Neches, Texas		
Kansas City, Mo.; Kansas City Section, I.S.A.; O. L. Boutros, 1627 E. 31st St., Kansas City 3, Kansas	**Sept. 10**[B], Main Auditorium, Univ. of K. C.	"Fundamentals of Pyrometry," W. H. Steinkamp, Brown Inst. Co.
Los Angeles, Calif.; California Section, I.S.A.; M. D. Pugh, 35 S. Raymond Ave., Pasadena 1		
Newark N. J.; **New Jersey Section, I.S.A.**; **H. S. Close, 831 Dixie** La., Plainfield, N. J.	**Oct. 1**[B], Essex House	"Shop and Equipment Requirements for an Instrument Dept. in a Large Plant in the Process Industry," W. Fortney, Humble Oil & Refining Co.
New Orleans, La.; New Orleans Section, I.S.A.; W. H. Haney, 1016 Esplanade Ave., New Orleans		
New York, N. Y.; New York Section, I.S.A.; C. D. Corey, Rieber Research Lab., 127 E. 73rd Street, New York 21		
N. Indiana; North Indiana Section, I.S.A.; C. P. Haynes, Red River Oil Ref., 935 177th Pl., Hammond, Ind.		
Philadelphia, Pa.; Philadelphia Section, I.S.A.; Clarence W. Wood, Mason-Neilan, 6908 Market St., Upper Darby, Pa.		
Pittsburgh, Pa.; Pittsburgh Section, I.S.A.; L. M. Susany, c/o Carnegie Institute, 4400 Forbes St.	**Oct. 28**[B], Roosevelt Hotel	"Manometer Applications in Industry," A. A. Hejduk, Meriam Instr. Co.
St. Louis, Mo.; Saint Louis Section, I.S.A.; H. E. Zeffren, 5625 Enright Blvd., St. Louis 12		
Kingsport, Tenn.; Tennessee Section, I.S.A.; C. F. Palmer, 2924 J. C. Hwy., Kingsport		
Toronto, Ont., Canada; Ontario Section, I.S.A.; T. C. Agnew, Minneapolis-Honeywell		
Washington, D. C.; Washington Section, I.S.A.; G. M. Rolls, c/o American Instrument Co., 8010-8020 Georgia Ave., Silver Springs, Md.		
Wyandotte, Mich.; **Wayne County Section, I.S.A.**; **Chas. Chessrown**, P. O. Box 150, Wyandotte	**July 22**, Wyandotte Chemicals Corp.	Conducted trip through dry ice department.

OTHER SOCIETIES

(Events of which *Instruments* has been notified.

City, Society, and Secretary	Date and Place	Subject and Speaker
Akron, Ohio; The Akron Instrument Society; Fred Appel, Jr., 932 Columbia Court, Barberton, Ohio.		
Atlanta, Ga.; Georgia Society for Measurement and Control; John Roberts, 439 Deering Rd.		
Ft. Worth, Tex.; Ft. Worth Electronics Club; W. H. Farrington		
Hartford, Conn.; Hartford Society for Measurement & Control; Gustave L. Manke, c/o Veeder-Root, Sargent & Garden Sts.		
Houston, Tex.; Houston Instrument Society; R. W. Fritsche, 630 A M & M Bldg., Houston 2		
Indianapolis, Ind.; Indianapolis Technical Instrument Society; Morris Underwood, Indianapolis Power & Light Co., Indianapolis 6		
Kalamazoo, Mich.; Southern Michigan Instrument Society; F. R. Brydges, 223 Chestnut St., Battle Creek.		
Los Angeles; Southern California Meter Association; Charles Meriam, Publicity Chairman, 960 Mission St., South Pasadena, Calif.		
Sarnia, Ont., Canada; Sarnia Instrument Association; K. Williamson, 168 Cobden St., Sarnia		
Southwest Texas; South Texas Instrument Society; Homer C. Givens, LaGloria Corp., Falfurrias, Tex.		
Whiting, Ind.; Whiting Instrument Men's Guild; Fred T. Lucas, 1713 Myrtle Ave., Whiting, Ind.		

[A]Meeting at 7:30, no dinner [B]Dinner at 6:30, meeting at 8 [C]Dinner at 7, meeting at 8 [D]Meeting at 8, no dinner [E]Dinner at 6:30, meeting at 7:30

Manufacturers' New Literature

In this department we report new literature pertaining to Instrumentation, received from the manufacturers. We urge readers to request ONLY those bulletins which will be of value to them. Use the Postage-free Order Card on page 443.

N-249 **Open-channel Meters.** 10-page 8" × 10½" Bulletin 62 illustrates and describes open-channel meters for sewage, industrial wastes, sludge, water supply, irrigation and liquids with solids in suspension. Operating data, charts and diagrams are included. Bailey Meter Co., Cleveland 10, Ohio.

N-250 **"Aminco Laboratory News."** 12-page 8½" × 11" Vol. 3, No. 1 of this house organ carries bits of news, technical information and illustrates and describes various instruments and laboratory equipment. Recent technical papers and new inventions are covered. American Instrument Co., Silver Spring, Md.

N-251 **Round-chart Potentiometers.** 16-page 8" × 10½" Catalog 15-5 illustrates and describes the "Brown Electronik Continuous Balance Potentiometer" with circular chart for recording and controlling. Instrument is said to be unaffected by vibration, can be positioned at any angle. Brown Instrument Co. Div. of Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

N-252 **Non-destructive Testing.** 4-page 8½" × 11" Bulletin 3000 illustrates and describes the "Sperry Supersonic Reflectoscope" which sends supersonic vibrations through material under test and measures length of time for reflecting from opposite side or from an internal defect. Sperry Products Inc., Hoboken, N. J.

N-253 **Precision Drill Press.** 4-page 8½" × 11" bulletin illustrates and describes a high-speed precision drill press designed exclusively for small-hole work in instrument departments, etc. Governor maintains exact spindle speed, with coarse or micro-feed. Electro-Mechano Co., 261 East Erie St., Milwaukee 2, Wisconsin.

N-254 **Ultra-high-frequency Vacuum Thermocouples.** 4-page 3½" × 8½" Bulletin V23 illustrates and describes small vacuum thermocouples for measuring current or voltage at ultra-high frequencies. It is said that only four seconds elapse between applications of heater current and full output from couple. Field Electrical Instrument Co., 109 E. 84th St., New York 53, N. Y.

N-255 **Tungsten-carbide Gage Blocks.** 8½" × 11" Data Sheet TC-1 describes 82-piece set of tungsten carbide gage blocks in sizes 0.050" to 4.000", said to be 100 times more resistant to abrasion than steel and to surpass Bureau of Standards requirements. Fonda Gage Co., 53 Daly St., Stamford, Conn.

N-256 **"The Hydromike."** 4-page 8½" × 11" Issue No. 26 of this house organ illustrates and describes snow-rain recorders: "Type W," 100" capacity which operates a year and "Series Q" which operates 64 days without attention. The "Type W" recorder can be supplied with radio transmission facilities for broadcast of precipitation catch at stated intervals. Featured is an article entitled "Man and Atoms." Leupold and Stevens Instruments, 4445 N. E. Glisan St., Portland 13, Ore.

N-257 **Indicator Light Assemblies.** 26-page 8½" × 11" Catalog No. 46 illustrates and describes what is said to be the largest selection of Underwriters' approved indicator light assemblies for panel board and instrument signaling, for any voltage and style of miniature lamp. Included are built-in resistor assemblies for neon lamps, brackets, accessories and diagrams with essential dimensions and other data. Gothard Manufacturing Co., 2110 Clear Lake Ave., Springfield, Ill.

N-258 **Protected Sling Psychrometer.** Single sheet 8½" × 11" pictures and describes a protected sling psychrometer with thermometers enclosed in plastic tube: when unit is whirled, centrifugal force creates a blast of air through the tube from center of rotation to free end of tube. Laboratory Specialties Inc., 144 So. Wabash St., Wabash, Ind.

N-259 **Low-capacity Rectifiers.** 4-page 8½" × 11" Bulletin No. 446 illustrates and describes a group of low-capacity copper-oxide rectifiers, square- and round-disk, full- and half-wave, d-c. output 5 to 50 milliamperes for instruments, test sets, and similar applications. Schauer Machine Co., 2060 Reading Road, Cincinnati 2, Ohio.

N-260 **"Weather Simulator."** 6-page 4" × 9" folder illustrates and describes cabinet said to be able to reproduce extreme climatic and weather conditions. Also covered are electric furnaces, drying ovens and constant temperature baths. The Electric Hotpack Co., Inc., 1225 Cottman St., Fox Chase, Philadelphia 11, Pa.

N-261 **Vibration Fatigue Testing Machine.** 4-page 8½" × 11" Bulletin 1007 illustrates and describes "Model 100VA" vertical vibration testing machine designed to handle loads to 100 lbs., equipped with automatic acceleration-changing feature, which starts with a frequency of 10 c.p.s., accelerates to 55 and decelerates to 10, every minute indefinitely unless interrupted. Other models are also covered. All American Tool and Mfg. Co., 1014 Fullerton Ave., Chicago 14, Ill.

N-262 **Voltage Regulator.** 4-page 8½" × 11" Bulletin No. 171-01 illustrates and describes "Type TH-2½A Transtat Alternating Current Voltage Regulator," continuously-adjustable from zero to above line voltage, adjusting potential to a load from an a-c. line and permitting control in small increments over wide range of voltages without opening circuit. American Transformer Co., 178 Emmet St., Newark 5, N. J.

N-263 **Potentiometer Air-operated Controller.** 16-page 8" × 10" Bulletin 15-4R illustrates and describes the "ElectroniK" circular chart potentiometer air-operated controller said to be the only potentiometer-type instrument in which the air control flapper mechanism is instantly positioned in response to temperature change and at no other time are operating parts in motion. Brown Instrument Co., Div. of Minneapolis-Honeywell Regulator Co., Philadelphia 44, Pa.

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RUBICON COMPANY

ELECTRICAL INSTRUMENT MAKERS

Ridge Ave. at 35th St., Philadelphia 32, Pa.

N-264 96% Silica Glass. 4-page 8½" × 11" Bulletin EL-Z-Z11 illustrates and describes "Corning Vycor No. 790 96% Silica Glass" available in tubing, rod, sheet, coil forms, cylinder and miscellaneous forms. Corning Glass Works, Corning, N. Y.

N-265 Combustibles Recorder. 4-page 7¾" × 10½" Bulletin 150 illustrates and describes an instrument giving a continuous record of combustibles content of a gaseous mixture, for controlled-atmosphere producers, controlled-atmosphere furnaces, chemical processes, boiler furnaces, and internal-combustion engine testing. Bailey Meter Co., Cleveland 10, Ohio.

N-266 Radio and Electronic Equipment Buying Guide. 114-page 6⅝" × 9½" Catalog No. 111 illustrates, lists and describes complete line of radio and electronic supplies. All equipment is presented in organized sections with items indexed for easy reference. Allied Radio Corp., 833 W. Jackson Blvd., Chicago 7, Ill.

N-267 Water Level Control at Parkchester. 8-page 8½" × 11" Bulletin 451 illustrates and describes the use of "Copes Flowmatic Regulators" on boilers which heat the world's largest housing project. Northern Equipment Co., Erie, Pa.

N-268 Vibration Damper. 8-page 8½" × 11" Bulletin No. BU50 illustrates and describes "Rubber - in - Shear Vibrating Dampner and Precision Leveler" machinery mounting, designed to stop transmission of vibration as well as to provide a means of leveling the machines. Bushings, Inc., Coolidge and 14 Mile Rd., Royal Oak, Mich.

N-269 Multiple-circuit Switches. 12-page 8½" × 11" Catalog No. 200 pictures and describes "Master" switches which, in combinations of thirty standard arrangements, are said to offer unlimited contact possibilities for opening and closing circuits, stopping and starting automatic machine cycles, lighting, actuating relays, valves, etc. General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.

N-270 Interference Viewer. 6-page 8½" × 11" folder illustrates and describes the "Optron" interference viewer for optical interference measurements. The surface being examined, either for flatness or for size, is both illuminated and viewed perpendicularly, thereby eliminating errors from angular distortion. The Optron Laboratory, 2655 Salem Ave., Dayton 6, Ohio.

N-271 Comparison and Limit Bridge. 4-page 8½" × 11" folder illustrates and describes "No. 1010 Comparison and Limit Bridge" for both precision testing and production inspection of resistors, capacitors and inductors. Freed Transformer Co., 72 Spring St., New York 12, N. Y.

N-272 Combustion Controller. 4-page 8½" × 11" bulletin pictures and describes "Type D636 Combustion Control," a hydro-electronic controller for continuous proportioning of fuel and air to steam demand. It is designed to function from either steam pressure or combination of steam pressure and steam flow. Shallcross Controls Inc., Milwaukee, Wis.

N-273 Rate-of-flow Indicator. 2-page 8½" × 11" Bulletin 360 illustrates and describes "Model FGG Flo-Gage," a midget rate-of-flow indicator for water, steam, air or gases through lines containing orifices, or other differential producers. Also for indicating liquid level and pressure differences. Builders-Providence, Inc., Providence 1, R. I.

N-274 Radio Testing Equipment. 4-page 8½" × 11" Bulletin F-13 pictures and fully describes dynamic and output tube testers, capacitor tester, test oscillators, a-c., d-c. electronic multimeters, industrial circuit testers, audio oscillators and cathode-ray oscillographs. Jackson Electrical Instrument Co., 18 South Patterson Blvd., Dayton 1, Ohio.

N-275 **Pressure-operated Switches.** 8-page 8½" × 11" bulletin illustrates and describes pressure-operated switches said to provide uniform pressure control from 30" of vacuum to 5000 lbs./in.² for aircraft, industrial and marine use in gas, steam, oxygen, or oil systems. Meletron Corp., 950 North Highland Ave., Los Angeles 38, Calif.

N-276 **Feed Water Control System for World's Largest Forced-circulation Boiler.** 16-page 8½" × 11" Bulletin 447 pictures and describes the use of "Copes" controllers and valves on world's largest forced-circulation boiler, at Somerset Station of Montaup Electric Co., Fall River, Mass. Northern Equipment Co., Erie, Pa.

N-277 **Pipe Locator.** 6-page 6" × 9" folder illustrates and describes with complete operating instructions the "Wahlquist Model 112" pipe locator consisting of a transmitter and a receiver. Transmitting oscillator remains stationary; receiver delivers amplified output to headphones. Nilsson Electrical Laboratory, Inc., 103 Lafayette St., New York 13, N. Y.

N-278 **Magnified Fluorescent Lighting.** 8-page 5½" × 8½" folder illustrates and describes the "Magnalite," a visual aid designed for doctors, dentists, first aid rooms, hospitals and inspection rooms. Two fluorescent tubes are mounted in a plastic head provided with a 5" magnifier, assembly mounted on a counterbalanced arm and self-supporting in any position. The Haas Corporation, Mendon, Michigan.

N-279 **Gravity Convection Ovens.** 6-page 8½" × 11" bulletin pictures and describes "Elconap" hot-air ovens with directed circulation of air currents. Temperature range of 180°C. makes units usable as ovens or hot-air sterilizers. Electric Heat Control Apparatus Co., Newark, N. J.

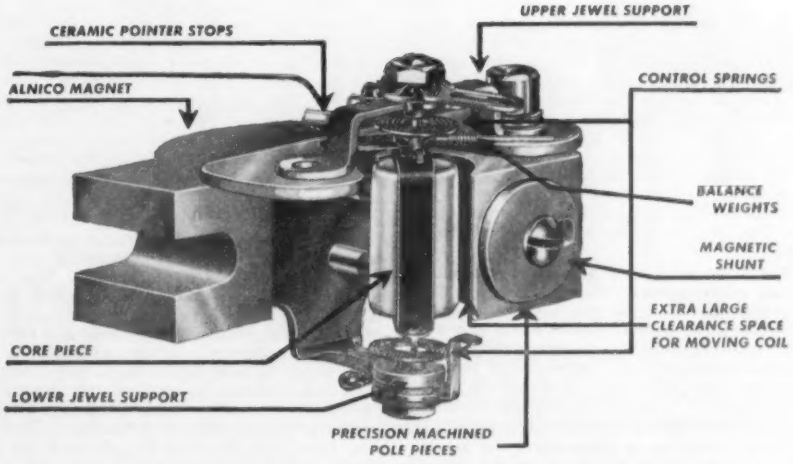
N-280 **Manually-operated Switches.** 8-page 8½" × 11" Catalog No. 100 illustrates and describes manually-operated switches for hand, elbow, knee or foot operation. Hand switches are of the "press anywhere" type; foot models are angled and flush-with-floor type, with or without guards. General Control Co., 1200 Soldiers Field Road, Boston 34, Mass.

N-281 **Dairy Thermometers.** 6-page 8" × 10½" Bulletin T825 illustrates and describes thermometers for the dairy industry for recording pasteurizing, sterilizing, cooling and holding temperatures. Water-proof case, corrosion-resisting sanitary construction meets all state and federal Health Department requirements. The Bristol Co., Waterbury 91, Conn.

N-282 **Open-hearth Immersion Pyrometer.** 4-page 7¾" × 10½" Folder N-33B illustrates and describes "Immersion Rayotube Pyrometer" consisting of four parts: an immersion tube with enclosed radiation-sensitive device sighting through an orifice at immersed end; an air control unit for controlling airstream which keeps immersion tube clear of molten metal and slag; a "Speedomax" recorder; and a checking unit. It is said that O-H temperatures are easily taken in less than two minutes. Leeds & Northrup Co., 4908 Stenton Ave., Philadelphia 44, Pa.

N-283 **Automatic Draft Control.** Single sheet 8½" × 11" Bulletin No. L-148-A illustrates and describes a furnace draft controller which opens damper before stoker can operate and closes damper when stoker operation is stopped. Draft switch is sensitive to 0.01" of water. Shallcross Controls, Inc., Milwaukee, Wis.

N-284 **Boiler Feed Water Regulators.** 8-page 7¾" × 10½" Bulletin No. 83-C describes and illustrates the "Thermo-Hydraulic Feed Water Regulators" which may be installed any place in the boiler feed line, above or below boiler water level, no piping changes being required. Bailey Meter Co., 1050 Ivanhoe Road Cleveland 10, Ohio.



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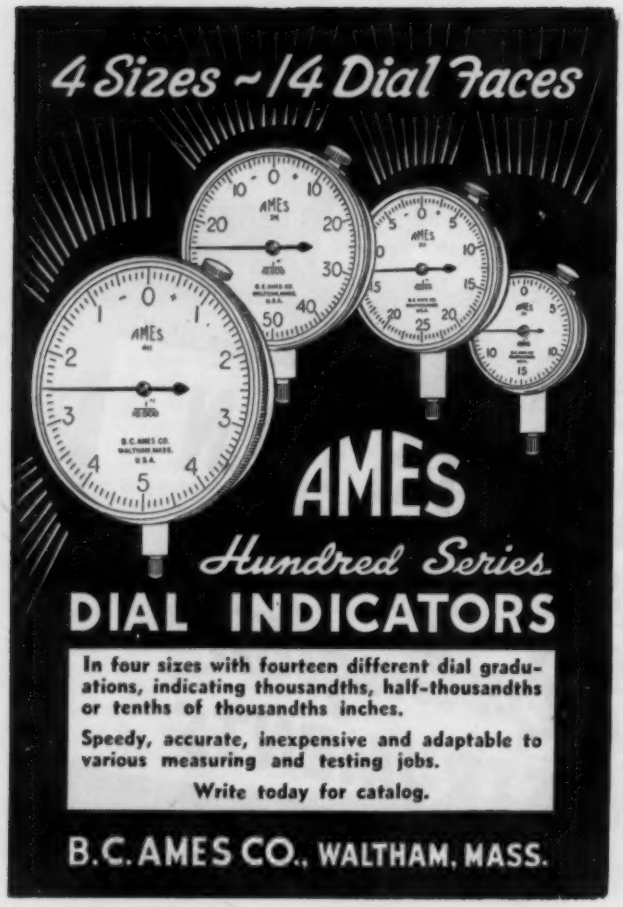
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N-285 **"The Solar System."** 16-page 5¾" × 8¾" May-June issue of this house organ (designated as Vol. 4, No. 1) designed for electronic engineers, servicemen and others, contains an article, "Solar and the Proximity Fuze," describing the part played by Solar capacitors in this development. Included are 1946 color codes for molded mica capacitors and a description of a capacitor-type a-c. follow-up motor. Solar Manufacturing Co., 285 Madison Ave., New York 17, N. Y.

N-286 **Switchboard and Portable Electrical Instruments.** 18-page 3¾" × 8½" Catalog No. 17 illustrates and describes ammeters, voltmeters and wattmeters of the moving-coil, electromagnetic and electro-dynamometer types. All moving systems are balanced in sapphire jewel bearings. Norton Electrical Instrument Co., Manchester, Conn.

N-287 **X-ray as a Foundry Tool.** 4-page 8" × 11" Reprint No. 1023 of an article from *Aluminum and Magnesium* covers the following topics: (1) how x-rays are produced, (2) equipment costs, (3) small casting production, (4) fluoroscopy, (5) personnel, and (6) operational costs. Radiographs, drawings and charts show defects encountered in magnesium castings. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.

N-288 **Small High-pressure Solenoid Valve.** 4-page 8½" × 11" Bulletin 462 describes and illustrates the "Allied V5-100 Three-way, Two-position Solenoid Valve" which is said, despite its small size, to operate at pressures up to 150 lbs./in.². Allied Control Valve Co., Inc., South Norwalk, Conn.

N-289 **Automatic Liquid Metering System.** 8-page 8½" × 11" Bulletin F-44 illustrates and describes the "Fluidometer" for automatic measuring of light or heavy liquids. It consists of three principal parts: a control unit, meter, and solenoid or motorized valve unit which may be compactly grouped or remotely placed. Hetherington and Berner, Inc., 701 Kentucky Ave., Indianapolis 7, Ind.

N-290 **Non-destructive Testing Method.** 4-page 8½" × 11" Bulletin 4000 illustrates and describes the "Sperry Electric Detector" for fast, low-cost, non-destructive testing of tubing, bar stock and lead sheath, by an electrical resistance method. Sperry Products, Inc., Hoboken, N. J.

N-291 **Geiger Counter Used in Powder Metallurgy.** 8½" × 11" Reprint No. R-1022 of an article appearing in *Iron Age* illustrates and describes use of Geiger-counter spectrometer for quick and accurate measurements of the intensities of x-ray reflection in the production of cemented-carbide products. X-ray intensities and diffraction angles are measured directly without intermediate photographic steps. North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.

N-292 **Optical Micrometer.** 4-page 8½" × 11" bulletin illustrates and describes "Aireon Optical Micrometer" for gaging of transparent plastics and glass in curved shapes and inaccessible spots, by microscopic focusing on a crayon mark on the far side of the part to be measured. Aireon Manufacturing Corp., 166 W. Olive Ave., Burbank, Calif.

N-293 **Photoelastic Stress Analysis.** 8-page 5¾" × 8½" Pamphlet 246-KP illustrates and describes photoelastic stress analysis, provides engineers and scientific investigators with a survey of the photographic aspects of this method. Subjects covered are: optical theory, apparatus, models, photographic materials and record analysis and three dimensional analysis. Eastman Kodak Company, Rochester 4, N. Y.

N-294 **Automatic Electronic Equipment Inspection.** 4-page 8½" × 11" bulletin illustrates and describes the "Rotobridge" for checking electronic equipment for circuit wiring errors, proper values of resistance, capacitance and inductance. It may also be employed as a continuity and leakage checker and for testing transformers. Tests are go-no-go type, may be made by unskilled help. Communication Measurements Laboratory, 120 Greenwich St., New York 6, N. Y.

N-295 **Oscilloscope Calibration.** Single sheet 8½" × 11" pictures and describes the "Voltascope," a small self-contained instrument employed to calibrate an oscilloscope under operating conditions. Instrument operates on a-c. power and is provided with switch and pilot light. Adjusted at the factory, it requires no further adjustment. Polarad Electronics Co., 135 Liberty St., New York 6, N. Y.

N-296 **Automatic Controllers.** 18-page 8½" × 11" Bulletin No. 12 illustrates and describes a group of thermostatic controls for dampers, stokers, fans and pumps. Damper control available in package units ready for installation. Sampsel Time Control, Inc., Spring Valley, Ill.

N-297 **Metallurgical Furnace.** 4-page 8½" × 11" Bulletin No. LT-4604 pictures and describes "Lab-Type" cylindrical controlled-atmosphere furnace convertible for salt or lead bath work. Furnace operates at temperatures up to 2000°F. with gas-tight retort temperatures to 1825°F. for carburizing, decarburizing, or for bright annealing in hydrogen atmospheres. Boder Scientific Co., 719 Liberty Ave., Pittsburgh 22, Pa.

N-298 **Vibration Exciter and Calibrator.** 4-page 8½" × 11" Bulletin No. 122 describes and illustrates "MB" vibration exciter and calibrator: a machine said to serve as a precision calibrator for vibration pick-up units, or as an exciter to shake out the trouble spots in machinery by finding resonances excited by vibration forces during operation. MB Manufacturing Co., Inc., New Haven 11, Conn.

N-299 **Stainless Steel Bellows.** 12-page 8½" × 11" Booklet No. SSB-46 describes and illustrates stainless steel bellows as equalizers, compensators, expansion joints, flexible connectors, for flow control, vapor and steam traps, thermostatic instruments, electrical controls, etc. Cross-section views, specification charts and other useful data for engineers and designers are included. Chicago Metal Hose Corp., Maywood, Ill.

N-300 **Test Plugs.** 2-page 8½" × 11" catalog section describes and illustrates production testing plugs for testing electronic equipment, analyzing circuit wiring and component parts by means of cables which are plugged into tube sockets. Communication Measurements Laboratory, 120 Greenwich St., New York 6, N. Y.

N-301 **Low-resistance Measurement.** 4-page 8½" × 11" Bulletin No. 1805 describes three instruments for measuring low resistances. "Bridge-Meg" combines an insulation resistance tester with a Wheatstone bridge. "Ducter" battery-operated tester measures ohmic resistances down to a few millionths of an ohm without manipulation. Midget "Megger" battery-operated circuit-testing direct-indication ohmmeter has range selection from 0 to 3 ohms up to 100 to 200,000 ohms. James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

N-302 **Precision Compass.** 8½" × 11" catalog sheet pictures and describes "Model 1576" illuminated compass for aviation and marine use, said to contain every known compensation and correction. Other features are, accuracy to within ±1°, finger tip compensation, movable lubber line, index line scale and course indicator. Sherrill Instrument Co., Sherrill Building, Peru, Ind.

N-303 **Duplicating Attachment for Machine Tools.** 8-page 8½" × 11" Bulletin CC-2 describes and illustrates a combined air- and hydraulically-controlled duplicating attachment which may be used on lathes or boring mills to produce workpieces with contours which exactly correspond to a thin metal template or master part. Attachment does not tie up machines, thereby permitting regular work at any time. Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio.

N-304 **Automatic Hydraulic Flow Regulator.** 4-page 8½" × 11" bulletin pictures and describes a constant-flow regulator for hydraulic systems. Diameter of regulator is a fraction of an inch more than that of line. Its use assures predetermined rate of flow regardless of pressure or back pressure. Flow in reverse direction is unlimited, permitting utilization where constant feed must be maintained. Waterman Engineering Co., 721 Custer Ave., Evanston, Ill.

N-305 **Boiler Feedwater Control.** 4-page 8½" × 11" Bulletin 103-C illustrates and describes "Fireye" electronic floatless boiler feedwater control, consisting of two units: a water level indicating probe-type fitting, operating on low voltage wired to a pump and alarm control. In the triple-probe type, top and middle probe determine high and low level; lowest probe defines danger point, shutting off fuel supply and sounding an alarm. Combustion Control Corp., 77 Broadway, Cambridge 42, Mass.

N-306 **Small Multiple-contact Electric Connector.** 4-page 8½" × 10½" bulletin pictures and describes "XL" series connectors, plug and receptacle type. Features are: Midget size, 2 3/32". overall length by ⅝" max. diameter; light weight, 0.0792 and 0.0992 lb. respectively; locking device; polarizing means; cable relief spring; silver plated brass contacts. Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Cal.

N-307 **Synchronizing Generator.** 8½" × 11" catalog sheet pictures and describes model PT101 "Polarad" television synchronizing generator applicable for tele-

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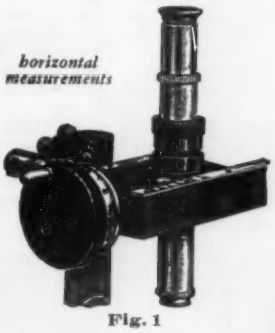

horizontal measurements

Fig. 1

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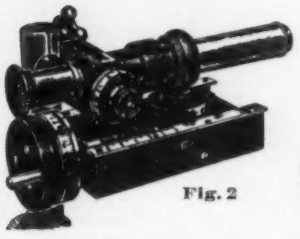
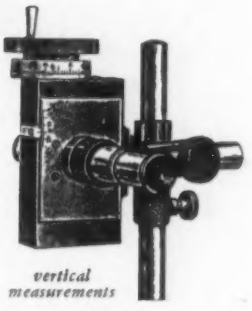


depth measurements

micrometer focusing

Fig. 2

Vertical orientation permits use as a small cathetometer for vertical linear measurements (Fig. 3). Interchangeability of microscope objectives and eyepieces permits a wide selection of magnifications.



vertical measurements

Fig. 3

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N-308 **Miniature Electrical Instruments.** 12-page 8½" × 11" Bulletin No. 105 describes and illustrates the "MB" line of miniature electrical instruments, said to have the accuracy requisite for industrial instrument use. Small size permits mounting in 1" to 1½" dia. panel opening. MB Manufacturing Co., Inc., Instrument Div., 331 East St., New Haven 11, Conn.

N-309 **"Aminco Laboratory News."** 8-page 8½" × 11" Vol. 3, No. 2 issue of this house organ contains articles of technical interest and the company's partial line of industrial laboratory and scientific instruments. Featured are a listing of the most important advances in science made during 1945 and "New Inventions and Discoveries" a listing of pertinent patents issued over a two-month period. American Instrument Co., 8030 - 8050 Georgia Ave., Silver Spring, Md.

N-310 **Regulated Power Supplies.** 2-page 8½" × 11" bulletin pictures and describes Models 1100 and 1110 regulated power supplies, differing only in panel arrangements, for laboratory or industrial use. Regulated high voltage and unregulated heater winding are isolated from each other and from chassis, making it possible to use these supplies as sources of "B" or "C" voltage. Communication Measurements Laboratory, 120 Greenwich St., New York 6, N. Y.

N-311 **Internal Comparator.** 8-page 8½" × 11" Bulletin No. 31 illustrates and describes shock-absorbing "Comtorplug" internal comparator for precision gaging. This gage permits accurate 2-point gaging, even in unskilled hands. It determines measurements to fractions of one ten-thousandth inch, reaching extreme bottom of blind holes or shoulders. Comptor Co., Waltham, Mass.

N-312 **Decade Units.** 8-page 8½" × 11" bulletin illustrates and describes dolly-mounted decade circuit components said to provide the engineer, professor and technician an almost limitless number of combinations: filter circuits, power supply loads, phase shift circuits, phase correction circuits, inductive or capacitive loads for testing relay contacts, resonance circuits, control circuits, and voltage divider circuits. Harvey-Wells Electronics, Inc., Southbridge, Mass.

N-313 **Electric Furnace.** 2-page 8½" × 11" Bulletin G2 pictures and describes "Temco Model GRP" electric furnace for the laboratory, research engineer, tool shop or plant. Top working temperature of 1500°F. may be reached in 30 minutes, and peak loads up to 1850°F. may be maintained for short periods. Pyrometer shows temperature in both °F. and °C. Thermo Electric Mfg. Co., 480 W. Locust St., Dubuque, Iowa.

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